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FIRE IN NORTH AMERICAN WETLAND ECOSYSTEMS AND FIRE–WILDLIFE RELATIONS: AN ANNOTATED BIBLIOGRAPHY

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Fire In North American Wetland Ecosystems and Fire-Wildlife Relations: An Annotated Bibliography

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Foreword

This *Biological Report* fills two important voids in the libraries of many wildlife biologists—an annotated bibliography on fire in North American wetland ecosystems and a subject index of all fire–related literature that has appeared in *Wildlife Review.*

We at Northern Prairie Wildlife Research Center have long been concerned about the role of fire in both upland and wetland communities, as fire is an important natural force affecting the nesting and feeding habitat of breeding waterfowl.

The early studies of fire–wildlife interactions conducted at this Center in the 1960's centered on attempts to restore native plant communities and reduce the abundance of Kentucky bluegrass and other introduced grasses in mesic prairies in the hopes that waterfowl nest densities and successs could be increased. Later and ongoing studies have emphasized the frequency and seasonality of prescribed burns needed to maintain these communities.

In the last decade or so, biologists from the Center and other wildlife agencies have become greatly concerned about the adverse effects of cattail and woody plant invasion in prairie wetlands. These plants have greatly reduced the attractiveness of wetlands for breeding waterfowl, while at the same time, they have increased the use of some of these wetlands as roosting sites for migrant blackbirds. Blackbirds sometimes cause serious depredation to sunflowers and certain other crops. Unfortunately, the problem of cattail invasion is especially severe on federally-owned Waterfowl Production Areas where, in most cases, both fire and grazing by livestock have been eliminated.

Clearly, these sites would benefit from more research on the effects of fire and grazing. I hope that this *Biological Report* will stimulate further research into fire ecology of wetlands in North America so that we may better manage our vital wildlife resources and maintain natural species diversity in these biologically rich ecosystems.

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Preface

Fire management activities have been elevated in importance in the Fish and Wildlife Service's management of the National Wildlife Refuge System (NWRS). This is reflected by the comprehensive documentation of fire management policies, objectives, standards, and guidelines found in the NWRS Refuge Manual (6RM7). Unfortunately, however, the scientific use of fire to ensure the perpetuation of viable wildlife populations and plant communities is, in many respects, still in its infancy. Nowhere is this more evident than in the use of fire to manage natural and man-created wetlands.

The literature review contained in this *Biological Report* was begun when the first and second authors were affiliated with the Division of Refuge Management, Wildlife Resources Program, U.S. Fish and Wildlife Service, Washington, DC. Therein, we were in daily contact with Refuge Managers and Regional Office personnel and came to appreciate the difficulties sustained in operating large-scale habitat management programs without the benefit of ready access to pertinent literature or the ability to locate persons with specific expertise. In particular, within our responsibility for coordinating research efforts on Refuge lands, we realized that in the area of fire management, it was sometimes impossible to formulate appropriate questions for research consideration—so little was known of specific fire effects and fire benefits. Thus, an interim bibliography was prepared in 1982 and distributed to requesters of information on use of fire in management of wetlands and other waterfowl habitat. Following several revisions, response to this interim effort suggested a more thorough treatment which ultimately led to the expanded bibliography in this *Biological Report.* This report's first section emphasizes the effects of fire on wetlands because this subject is in need of review given current management priorities for Service lands. The document's second section provides a broader review of the effects of fire on wildlife in all habitats and will assist integration of wetland management via use of fire with management of surrounding terrestrial habitat and associated wildlife populations.

With the exception of the short bibliographies by Rutkosky (1978) and Kantrud (1986), this is the first attempt to provide a multidisciplinary review of the fire–wetlands literature, and certainly the most comprehensive compilation of fire–wildlife literature to date. Our close association with this project leads us to conclude, however, with some dismay, that a predictive science for this field is a distant goal. Nonetheless, wetland managers and others interested in the use of fire may now have access, through this report, to the major portion of the pertinent literature. It is our intent that this bibliography assist managers to plan efforts to obtain site-specific data, either through evaluation of management efforts or initiation of research, that will permit a much closer approach to the use of fire as a scientific tool for wetlands management.

Summary

The relation of fire to wetland ecosystems is reviewed to prepare an annotated bibliography of 319 citations that provide specific research data, summaries of existing knowledge, or site-specific management advice for North America. To this bibliography is appended a supplemental bibliography of all articles cited in the U.S. Fish and Wildlife Service publication series, *Wildlife Review*, years 1935 through the September 1987 issue (Number 206) that discussed any aspect of wildlife management and ecology related to fire management, fire behavior, or fire effects in North America. The annotated bibliography is intended to provide access to literature on fire–wetlands relations and to provide initial guidance in preparation of fire management planning documents on Service lands. The 942 citations in the supplemental bibliography are intended to provide a ready reference to the fire–wildlife literature that can be used to evaluate past, current, or proposed use of fire in wildlife habitat management. Guidance for obtaining the literature cited in both sections is provided.

Acknowledgments

This bibliography is one result of ongoing effort to increase the biological management capabilities of the Services' operational arms. Cooperators in compiling this bibliography were the Fish and Wildlife Service's Research and Development Office of Information Transfer and the Division of Refuges staff of the Assistant Director for Refuges and Wildlife. The support of J.F. Gillett, J.R. Eadie, and L.F. Beaty (respectively Chief, Deputy Chief, and Chief of the Branch of Resource Management of the Division of Refuge Management when this project was initiated); and R.E. Gilmore (previously Deputy Associate Director, National Wildlife Refuge System) in this cooperative effort is acknowledged. We also acknowledge F.A. Belcher, J.E. Cornely, A.D. Kruse, A.R. Taylor, and D.Q. Thompson for their review of early drafts. K.F. Higgins, L.M. Smith, and R.W. Wein provided comments on the penultimate draft and suggested additional references, but we assume responsibility for any deficiencies. Assistance by the Colorado State University's Morgan Library Science Reference staff, Fort Collins, CO, in obtaining interlibrary loan material, and the assistance of the following in obtaining other items was invaluable to this review: the Department of the Interior Natural Resources Library, Washington, DC, particularly B.L. Graff; L.J. Garrett (Patuxent Wildlife Research Center, Laurel, MD); A.M. Kokott and A. Zimmerman (Northern Prairie Wildlife Research Center, Jamestown, ND); D.L. Dwyer (Denver Wildlife Research Center, Denver, CO); M.W. Herschcopf (Colorado Divison of Wildlife, Wildlife Research Center, Fort Collins, CO); and F.J. Barney (Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO). The original photograph on which the cover was based was provided by J. Wilbrecht of National Elk Refuge. Funding for this publication was obtained from the Office of Information Transfer and the Division of Refuges.

Contents

Index to Scientific and Common Names Used in the Text

The span of years covered in the annotated bibliography lead to difficulty in presenting consistent nomenclature for animals and plants addressed in the various texts. This was because of both changes in the accepted scientific nomenclature and the extensive use in earlier writings of locally prevalent English names for many organisms, especially plants. For ease of comparison of the annotations, we have therefore chosen a list of English and scientific names to use in this bibliography irrespective of the nomenclature used in the original text. Thus, in the body of the text, each species is always referred to with a single English and a single scientific name unless an outdated common name appears in a title, in which case a translation is made. Further, to ease scanning of the citations, with few exceptions we have chosen to use only the selected English in the annotations. Easy reference to appropriate scientific names is obtained by use of Table 1, which contains each scientific and English name used in the titles and texts of the entries in the annotated bibliography.

Although accepted references exist for the scientific nomenclature of all organisms, similar guides are not available for all English names, and some species have no English name. The scientific and English names we have selected were obtained from the standard works listed below. For consistency with current wildlife, but not necessarily accepted botanical literature, plant names in Scott and Wasser (1980) were given precedence throughout except for names of trees which follow Little (1979). A recent summary of all vertebrate names mentioned in the text is R.C. Banks, R.W. McDiarmid, and A.L. Gardner (1987. Checklist of vertebrates of the United States, the U.S. Territories, and Canada. U.S. Fish Wildl. Serv., Resour. Publ. 166. 79 pp.)

Amphibians and Reptiles

Collins, J.T., J.E. Huheey, J.L. Knight, and H.M. Smith. 1978.Standard common and scientific names for North American amphibians and reptiles.Society for Study of Amphibians and Reptiles.Herp. Circ. 7. 36 pp.

Birds

American Ornithologists' Union. 1983. Check list of North American Birds. 6th ed. The American Ornithologists' Union, Washington, DC. 877 pp.

Invertebrates

Sutherland, D.W.S. 1978. Common names of insects and related organisms (1978 revision). Entomol. Soc. Am. Spec. Publ. 78-1. 132 pp.

Mammals

Jones, J.K., Jr., D.C. Carter, H.H. Genoways, R.S. Hoffmann, and D.W. Rice. 1982. Revised checklist of North American mammals north of Mexico, 1982. Occas. Pap., Mus. Tex. Tech. Univ. 80. 22 pp.

Plants

Correll, D.S., and H.B. Correll. 1975. Aquatic and wetland plants of southwestern United States. 2 vol. Stanford University Press, Stanford, CA. 1777 pp.

Godfrey, R.K., and J.W. Wooten. 1979. Aquatic and wetland plants of southeastern United States. Monocotyledons. University of Georgia Press, Athens. 712 pp.

Godfrey, R.K., and J.W. Wooten. 1981. Aquatic and wetland plants of southeastern United States. Dicotyledons. University of Georgia Press, Athens. 933 pp.

Ireland, R.R. 1982. Moss flora of the Maritime Provinces. Nat. Mus. Can. Publ. Bot. 13. 738 pp.

Little, E.L., Jr. 1979. Checklist of United States trees (native and naturalized). U.S.Dep.Agric. For. Serv., Agric. Handb. 541.375 pp.

McGregor, R.L., T.M. Barkley, R.E. Brooks, and E.K. Schofield, editors. 1986. Flora of the Great Plains. University Press of Kansas, Lawrence. 1392 pp.

Scott, T.G., and C.H. Wasser. 1980. Checklist of North American plants for wildlife biologists. The Wildlife Society, Washington, DC. 58 pp.

Table 1. *Common and scientific names of organisms mentioned in the titles or text of the annotated bibliography entries.*

Common name	Scientific name
alders	*Alnus* spp.
alligator, American	*Alligator mississippiensis*
ash, Carolina	*Fraxinus caroliniana*
aspens	*Populus* spp.
Asteraceae (composite family)	Asteraceae = Compositae
baldcypress	*Taxodium distichum*
barnyardgrasses	*Echinochloa* spp.
barnyardgrass, coast	*Echinochloa walteri*
bay (= sweetbay, swampbay, loblolly-bay)	
bear, black	*Ursus americanus*
beaver	*Castor canadensis*
bison	*Bison bison*
black-mangrove	*Avicennia germinans*
bluestems	*Andropogon* spp.
bobwhite, northern	*Colinus virginianus*
brome, smooth	*Bromus inermis*
bulrushes	*Scirpus* spp.
bulrush, alkali	*Scirpus maritimus*
bulrush, American	*Scirpus americanus*
bulrush, hardstem	*Scirpus lacustris*
bulrush, Olney	*Scirpus olneyi*
bulrush, river	*Scirpus fluviatilis*
bulrush, saltmarsh	*Scirpus robustus*
bulrush, softstem	*Scirpus validus*
bulrush, tule	*Scirpus acutus*
burreed	*Sparganium* spp.
burreed, giant	*Sparganium eurycarpum*
button-mangrove	*Conocarpus erectus*
cajeput tree	*Melaleuca quinquenervia*
cane	*Arundinaria*
cane, giant	*Arundinaria gigantea*
canvasback	*Aythya valisineria*
caribou	*Rangifer tarandus*
cattails	*Typha* spp.
cattail, common	*Typha latifolia*
cattail, narrowleaf	*Typha angustifolia*
cattle (domestic)	*Bos taurus*
cestodes	Cestoidea (Cestoda)
chipmunk, least	*Tamius minimus*
cladonia (lichen)	*Cladonia* spp.
coot, American	*Fulica americana*
cordgrasses	*Spartina* spp.
cordgrass, big	*Spartina cynosuroides*
cordgrass, gulf	*Spartina spartinae*
cordgrass, marshhay	*Spartina patens*
cordgrass, smooth	*Spartina alterniflora*
cotton rat, hispid	*Sigmodon hispidus*
cottonsedges	*Eriophorum* spp.
cottonsedge, sheathed	*Eriophorum vaginatum* subsp. *spissum*
crane, sandhill	*Grus canadensis*
crow, American	*Corvus brachyrhynchos*
crowberry, black	*Empetrum nigrum*

Table 1. Continued.

Common name	Scientific name
curlew, long-billed	*Numenius americanus*
cutgrass, rice	*Leersia oryzoides*
Cyperaceae (sedge family)	Cyperaceae
cypresses	*Taxodium* spp.
deer	*Odocoileus* spp.
deer, white-tailed	*Odocoileus virginianus*
dove, mourning	*Zenaida macroura*
Drepanocladus (moss)	*Drepanocladus* spp.
duck, mottled	*Anas fulvigula*
ducks	Anatinae
duckweeds	*Lemna* spp.
feathermoss, red-stemmed	*Pleurozium schreberi*
fetterbushes	*Leucothoe* spp.
fir, Douglas	*Pseudotsuga menziesii*
fish	Pisces
fisher	*Martes pennanti*
flatsedge, redroot	*Cyperus erythrorhizos*
foxtails	*Alopecurus* spp.
geese	Anserinae
goat, mountain	*Oreamnos americanus*
godwit, marbled	*Limosa fedoa*
goose, Canada	*Branta canadensis*
goose, snow	*Chen caerulescens*
grass	Poaceae
grasshoppers	Acrididae
greasewood, black	*Sarcobatus vermiculatus*
greenbriers	*Smilax* spp.
ground squirrel, thirteen-lined	*Spermophilus tridecemlineatus*
grouse, ruffed	*Bonasa umbellus*
grouse, sharp-tailed	*Tympanuchus phasianellus*
grouse, spruce	*Dendragapus canadensis*
hawk, white-tailed	*Buteo albicaudatus*
heath	Ericaceae
herons	Ardeidae
huisache	*Acacia farnesiana*
jumping mouse, meadow	*Zapus hudsonius*
katydids, meadow	*Conocephalus* spp.
killdeer	*Charadrius vociferus*
larch, tamarack	*Larix laricina*
leatherleaf, Cassandra	*Chamaedaphne calyculata*
lichen	Lichenes
loblolly-bay	*Gordonia lasianthus*
lyonia, fetterbush	*Lyoina lucida*

Table 1. Continued.

Common name	Scientific name
mallard	*Anas platyrhynchos*
mangrove	See red mangrove, black-mangrove, white-mangrove, button mangrove
mangrove, red	*Rhizophora mangle*
maple, red	*Acer rubrum*
marshpurslane, slimfruit	*Ludwigia leptocarpa*
marten	*Martes americana*
meadowlark, eastern	*Sturnella magna*
mints	*Mentha* spp.
mites	Acarina
moose	*Alces alces*
moss, mountain fern	*Hylocomium splendens*
mosses, peat	*Sphagnum* spp. *Sphagnum fuscum* *Sphagnum girgensohnii*
moss, plume	*Ptilum crista-castrensis*
moss, Spanish	*Tillandsia usneoides*
mouse, deer	*Peromyscus maniculatus*
mud turtle, eastern	*Kinosternon subrubrum subrubrum*
muskrat	*Ondatra zibethicus*
muskrat, round-tailed	*Neofiber alleni*
needle rush	*Juncus roemerianus*
nutria	*Myocastor coypus*
oaks	*Quercus* spp.
orchid	Orchidaceae
otter, river	*Lutra canadensis*
palmettos	*Sabal* spp.
panicums	*Panicum* spp.
panicum, maidencane	*Panicum hemitomon*
paspalum, knotgrass	*Paspalum distichum*
paspalum, seashore	*Paspalum vaginatum*
periwinkles	*Littorina* spp.
pickerelweed, lance	*Pontederia lanceolata*
pines	*Pinus* spp.
pine, longleaf	*Pinus palustris*
pine, pitch	*Pinus rigida*
pine, pond	*Pinus serotina*
pine, ponderosa	*Pinus ponderosa*
pine, slash	*Pinus elliotti*
pintail, northern	*Anas acuta*
pinyon	*Pinus edulis*
pitcherplants	*Sarracenia* spp.
pitcherplant, pale	*Sarracenia alata*
Poaceae (grass family)	Poaceae = Gramineae
pocket mice	*Perognathus* spp.
pondcypress	*Taxodium distichum* var. *nutans*
ptarmigans	*Lagopus* spp.

Table 1. Continued.

Common name	Scientific name
rabbits, (cottontails)	*Sylvilagus* spp.
rabbitbrush, rubber	*Chrysothamnus nauseosus*
raccoon	*Procyon lotor*
rails	Rallidae
redbay	*Persea borbonia*
redroot	*Lacnanthes tinctoria*
redwood, coast redwood	*Sequoia sempervirens*
reed, common	*Phragmites australis* (formerly *Phragmites communis*
reedgrass, bluejoint	*Calamagrostis canadensis*
rivergrass, whitetop	*Scolochloa festucacea*
rush, Baltic	*Juncus balticus*
rush, needle	*Juncus roemerianus*
sacaton, big	*Sporobolus wrightii*
saltgrass, seashore	*Distichlis spicata*
sawgrass	*Cladium jamaicense*
sedges	*Carex* spp.
sedge, awned	*Carex atherodes*
sequoia, giant	*Sequoiadendron giganteum*
sesbania, hemp	*Sesbania exaltata*
sheep, bighorn	*Ovis canadensis*
shrews	Soricidae
shrew, masked	*Sorex cinereus*
shrew, northern short-tailed	*Blarina brevicauda*
smartweeds	*Polygonum* spp.
smartweed, swamp	*Polygonum hydropiperoides*
snail, salt marsh	*Melampus bidentatus*
snakes	Serpentes
snipe, common	*Gallinago gallinago*
southern-wildrice, giant	*Zizaniopsis miliacea*
sparrow, LeConte's	*Ammodramus leconteii*
sparrow, Savannah	*Passerculus sandwichensis*
sphagnum (peat moss)	*Sphagnum* spp.
spikerush, common	*Eleocharis palustris*
sprangletops	*Leptochloa* spp.
spruces	*Picea* spp.
spruce, black	*Picea mariana*
squirrel, red	*Tamiasciurus hudsonicus*
squirrels, tree	*Sciurus* spp.
swampbay	*Persea palustris* *Persea borbonia* var. *pubescens*
sweetbay	*Magnolia virginiana*
sweetgum	*Liquidambar styraciflua*
tamarack larch	*Larix laricina*
teal, blue-winged	*Anas discors*
thistle, Canada	*Cirsium arvense*
threeawns	*Aristida* spp.
threeawn, pineland	*Aristida stricta*
treefrog, pine barrens	*Hyla andersonii*
trematodes	Trematoda (Platyhelminthes)
trumpet-leaf	*Sarracenia flava*

Table 1. Continued.

Common name	Scientific name
tupelos	*Nyssa* spp.
tupelo, black	*Nyssa sylvatica*
tupelo, swamp	*Nyssa sylvatica* var. *biflora*
tupelo, water	*Nyssa aquatica*
vole, meadow	*Microtus pennsylvanicus*
waterfowl	Anseriformes
white-cedar, Atlantic	*Chamaecyparis thyoides*
white-cedar, northern	*Thuja occidentalis*
white-mangrove	*Laguncularia racemosa*
widgeongrass	*Ruppia maritima*
wildrye, basin	*Elymus cinereus*
wildrye, creeping	*Elymus triticoides*
willows	*Salix* spp.
willow, coastal plain	*Salix caroliniana*
wintergrass, Texas	*Stipa leucotricha*
wren, sedge	*Cistothorus platensis*
yellowlegs, greater	*Tringa melanoleuca*
yellowlegs, lesser	*Tringa flavipes*
zenobia	*Zenobia pulverulenta*

Fire in North American Wetland Ecosystems and Fire–Wildlife Relations

Introduction

Throughout postglacial time, and most likely in earlier periods as well, fire has had substantial influence on life and landscape in North America. This influence has been through modification of vegetation and soils, and subsequently, on dependent fauna, water resources, microclimate, air quality, and perhaps even general climate during extreme conflagrations. Although many of the immediate effects of fire fall into the "common knowledge" category, long-term effects upon the ecosystem are less well known. Thus, although the successional stages following fire are recognized as resulting in generally predictable soil, floral, and faunal development, the exact mechanisms through which various factors affect the growth, development, range expansion, and relative dominance of both plant and animal species following fire is still an area of major study.

Only in recent decades has it become clear that both uncontrolled fire and complete fire exclusion can be detrimental to ecosystems that have developed in fire regimes different from those selected by man. Scientists have accepted the role that fire plays in both long- and short-term shaping of plant communities and their associated fauna. Many, however, still regard fire as completely destructive, a view that is not surprising considering the scale and frequency of major conflagrations that have occurred in North America since the arrival of European man. [An excellent review of man's view of fire is provided by S. J. Pyne (1982; Fire in America—a cultural history of wildland and rural fire. Princeton University Press, Princeton, NJ. 654 pp.). Similarly, Higgins (1986)[1] provides a review of aboriginal fire in North American prairies.]

Fire affects the interdependent components of the ecosystem simultaneously with the result that synergistic interactions are easily identified at all levels of investigation. Although this is clearly recognized, investigators and managers often wish to know the details of the effects of fire (both harmful and beneficial) on identifiable portions of the ecosystem. In response, several major reviews (Ahlgren and Ahlgren 1960; Kozlowski and Ahlgren 1974; Lyon et al. 1978; Martin et al. 1979; Tiedemann et al. 1979; Wells et al. 1979; Sandburg et al. 1980; Lotan et al. 1981; Wright and Bailey 1982) have compiled information on the effect of fire on individual plant communities, groups of organisms, and physical aspects of the environment. This material leads to the inescapable conclusion that studies of the interaction of any terrestrial and many aquatic organisms with their environment are incomplete if fire effects are not taken into account.

In contrast to a wealth of data on the effects of fire in grasslands, shrublands, forests, and other terrestrial habitats, the information on the effects of fire upon wetlands is sparse, scattered throughout the literature, and lacks a comprehensive synthesis. Thus, although one may find reviews of the effects of fire upon watersheds as a whole, or streams, rivers, or lakes as a whole, the effects of fire upon wetland vegetation and wetland wildlife have, for the most part, been restricted to site-specific studies. This is not to say, however, that fire is an unused tool in wetlands management or that fire effects in wetland habitats are completely unknown. In fact, quite the contrary is true for fire has long been used to control wetland succession in coastal marshes, is a recognized tool for control of undesirable or noxious wetland plants in both coastal and inland wetlands, and its effects upon both permafrost areas and peatlands in general have long been appreciated. Nonetheless, Trippensee's (1953) classic Wildlife Management (Vol. 2) only briefly mentioned fire as a management tool of positive value, reflecting the extreme emphasis of the time on fire suppression. Slightly more

[1]Citations referenced here and following with surnames and dates are included in the annotated bibliography.

recent U.S. Government documents (Martin et al. 1957; Davison and Neely 1959) from the Departments of Interior and Agriculture, respectively, emphasized the necessity to use fire in management of wetlands, even though only general prescriptions could be provided. Contemporary wetland management "handbooks" such as those written by Linde (1969) and Schnick et al. (1982) provide, at best, slight expansions upon earlier general advice, with fire recognized as being of value, but with the authors providing only general management advice from a few site-specific studies to guide the wetlands manager. Not until Linde's (1985) review was an integrated assessment of a number of wetland management techniques, including fire, presented, but the prescriptions were limited in universal application by the specific focus on man-made impoundments in the Great Lakes States. Linde's (1985) discussion reiterated, with more detail, the advice available in Martin et al. (1957) and Davison and Neely (1959), indicating only slight progress. Thus, throughout, one finds substantially less rigor in evaluation of fire–wetlands relations than one finds in modern texts on range management, or management of species of commercially important trees, indicating the need for further research and synthesis (cf Kantrud 1986).

Why an emphasis upon fire and its effects upon wetlands? One reason is that wetlands and other aquatic habitats make up more than 13.8 million ha (34 million acres) approximately 38%, of the National Wildlife Refuge System. But perhaps the best answer is indicated within the recent review of wetland trends in the United States (W. E. Frayer et al 1983; Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950's to 1970's. Department of Forestry and Range Science, Colorado State University, Fort Collins. 32 pp.) which showed a net wetland and deepwater habitat loss of 1.25 million ha for the period, and an average annual net loss of 154 thousand ha. Despite the formation of new lacustrine deepwater habitats (lakes), palustrine open water (ponds), and estuarine subtidal deepwater habitats (bay bottoms), the wetland base of the United States nonetheless decreased from 43.7 million ha in the 1950's to 40.1 million ha in the 1970's, a net loss of 3.6 million ha of inland and coastal wetlands. In terms of what was once available as wetland habitat, probably less than 46% remains of the original 87 million ha in the conterminous United States (R. W. Tiner, Jr. 1984. Wetlands of the United States: current status and recent trends. U.S. Fish and Wildl. Serv., National Wetlands Inventory, USGPO, Washington, DC 59pp.) These figures make clear both the substantial current loss and the continuing trends in wetland areal loss in the United States.

As more information on the value of wetlands has accumulated, the value of each remaining wetland (as the total wetland base shrinks) has become relatively greater. Thus, there is an ever-greater need for natural resources managers to use every tool at their disposal to efficiently and effectively manage wetlands for a multitude of human and wildlife benefits. This is especially true of the Fish and Wildlife Service, whose responsibility for managing wetlands comes largely from international treaties concerning migratory birds, the Federal Government's Fish and Wildlife Coordination Act, the Service's role as a reviewer of Federal projects and applications for Federal permits that require wetland alteration, the Endangered Species Act of 1973, and the National Environmental Policy Act of 1969.

Wetland management as a whole is poorly founded in theory and as a predictive science (M. W. Weller. 1978. Management of freshwater marshes for wildlife. Pages 267–284 *in* R. E. Good et al., eds. Freshwater wetlands, ecological processes and management potential. Academic Press, New York). This is especially true with regard to use of fire as a management tool in wetlands, largely because so little work that is of a specifically comparative nature or that strictly tests hypotheses has been conducted. [M. W. Weller (ibid) specifically suggested that burning and grazing were wetland management practices most in need of study.] This does not mean, however, that general guidelines cannot be obtained from the literature, or that guidance on both best management practices for various wetland types and areas in need of further research is totally lacking. A surprising amount of information on fire–wetlands relationships is available. The interested

manager will find a wealth of material pertinent to wetland management and fire management planning in the following bibliography.

Development of the Bibliography

Items included in this bibliography had to be published and had to address the use or the effects of fire in wetland ecosystems. Wetlands are defined as "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" (L. M. Cowardin et al. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish Wildl. Serv. FWS/OBS-79/31. 103 pp.). With the exception of theses and dissertations, we did not include unpublished literature (in-house studies, progress reports, etc. from government agencies), even though it is voluminous on the subject of fire–wetland relations. These latter items are available through searches of commercial databases, particularly the Fish and Wildlife Reference Service which includes reports from Pittman-Robertson and Dingle-Johnson Fish and Wildlife Restoration projects and the National Technical Information Service which offers a host of other unpublished government reports.

A primary data source for this bibliography was FIREBASE, a computerized data base covering all aspects of wildfire and prescribed burning, developed by the U.S. Forest Service (Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory, Missoula, MT 59801). Other major sources included the following: the U.S. Fish and Wildlife Service bibliography on the subject prepared in the mid-1970's (Rutkosky 1978); *Proceedings of the Annual Tall Timbers Fire Ecology Conference; Wildlife Abstracts; Wildlife Review; The Journal of Wildlife Management; Transactions of the North American Wildlife* (later *Wildlife and Natural Resources) Conference; Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners*; the Federal documents indexed in the Federal Depository Library of Colorado State University; the holdings of the Natural Resources Library, Department of Interior, Washington, DC; the holdings of the Rocky Mountain Forest and Range Experiment Station Library, U.S. Forest Service, Fort Collins, CO; several published and unpublished reviews of the wetlands literature; and other documents cited in books and key papers which came to our attention during literature review. Additionally, we exhaustively searched the files of the commercial database provided by DIALOG Information Retrieval Services, Incorporated, Palo Alto, CA in 1983, and following the major drafting of the bibliography, again reviewed the DIALOG files in 1987. Several bibliographies on fire and fire effects were particularly helpful in providing access to the older literature. They are included in the annotated bibliography so that those with broader concerns may easily initiate literature reviews with different emphases.

The bibliography covers the literature available through July 1987 and is an attempt to be as complete as possible. We acknowledge, however, that despite diligent review, some pertinent articles may have escaped inclusion. This may be true particularly with regard to Master's theses that were never published and therefore received little citation in the published literature. Nonetheless, as with any literature review, some limits were developed for the compilation that require several qualifications to be applied to the claim of "completeness" of coverage. First, we consciously limited the overall scope of the review to the North American literature and within that, further limited our coverage to only specific subsets of the total available literature. In order to keep the annotated bibliography to a reasonable size and to limit its potential redundancy to other bibliographies and on-line databases, we took several arbitrary steps. For example, we recognized early in our literature review that many articles on boreal forest and taiga ecosystems provided little information on the specific effects of or results from fire on wetlands in these systems even though fire was addressed [cf J. A. Larsen 1980. The boreal ecosystem. (Physiological Ecology Series, T. T. Kozlowski, ed.). Academic Press, New York.

500 pp. for a recent review with a focus on ecosystem relationships including general effects of fire]. Of more concern, however, was the large number of literature citations resulting from the rapid escalation of ecological investigations in the Far North, especially Alaska. We therefore included only selected documents on far northern ecosystems, and have emphasized recent compilations of the literature for these areas rather than the entire range of published studies. Similarly, many investigations of fire effects upon watersheds discuss changes in lake and stream chemistry, flow, and fauna. The focus of most of these, however, has been on short- and long-term effects upon nutrient and other chemical releases from entire watersheds, so we limited inclusion of these papers to those that discussed effects upon aspects other than the water column per se. Finally, the paleoecological and geological literature contain many studies that describe past environments and floral composition based upon analyses of lake stratigraphic sequences, pollen records, and coal deposits. Since fire's presence is usually only identified in these reviews, we deleted references that did not relate review of the historical record to present conditions and the current management of the wetlands involved.

Although the above limitations provided clear guidelines for inclusion of citations, we nonetheless wished to make this document a useful starting point for any investigation of fire-ecosystem relations. Thus, to make the review of more general value to the reader interested in a broad range of fire relations, we have included several review publications prepared by the U.S. Forest Service on overall fire effects (Lyon et al. 1978; Martin et al. 1979; Sandburg et al. 1980; Tiedemann et al. 1979; Wells et al. 1979; Lotan et al. 1981); several acknowledged major references on fire and fire effects (Brown and Davis 1973; Kozlowski and Ahlgren 1974; Wright and Bailey 1982), and several historically important review papers (U.S. Forest Service Library 1938; Folweiler and Brown 1946; Lutz 1956; Ahlgren and Ahlgren 1960).

The abstracts provided herein were obtained from several sources. When possible, authors' original abstracts or summaries, modified for clarity or brevity, were reproduced (denoted as "from authors' abstract"). If no abstract or summary was available, we prepared one (denoted as "K–L–S"). Many of the abstracted papers did not have fire effects as their major focus. Nonetheless, our abstracts emphasize the concern of this bibliography and do not provide details on the remainder of the document unless the subject matter is not clear from consideration of the title alone. An author index and a cross-referenced subject index follow the annotated abstracts.

Discernible Trends in the Fire–Wetlands Literature

Surprisingly few papers have addressed aspects of fire–wetlands relations; fewer yet have had this subject as a major focus of investigation. In general, fire has been treated as one of a number of management tools appropriate for wetlands, with its major use that of eradication of undesirable vegetation. Unlike the literature on fire in terrestrial upland communities, however, specific fire prescriptions, knowledge of fire behavior under different fuel loadings and environmental conditions, and the detailed consequences of differing fire frequencies, fire intensities, and fire severities in wetlands are largely unknown. As a physical phenomenon, fire in wetlands has only been studied in detail for deep peat soils, where extinguishing a fire can be difficult or well nigh impossible. However, recent studies have begun to emphasize nutrient release, mineral cycling, and other chemical effects of fire upon the soil and subsequent vegetative vigor and productivity.

The earliest references to fire in North American wetlands are the anecdotal accounts of early travelers in the Upper Midwest and Great Plains [recently compiled by Higgins (1986)], that mention fire in lowland areas in the late 1600's. The first North American reference to the value of fire in managing wetlands for wildlife (waterfowl) appears to be that of Furniss (1938), although L. J. Bennett (1938. The Blue-winged Teal, its ecology and management. Collegiate Press, Ames, IA. 144 pp.) mentioned in passing in the same year that breeding habitat conditions for upland-nesting

waterfowl could be improved by selective use of fire. The role of fire in maintaining certain plant communities was appreciated long before this, however. Korstian (1924) and Korstian and Brush (1931) identified fire as a major determinant in the establishment and maintenance of Atlantic white-cedar communities; Lewis and Dowding (1926) and Lewis et al. (1928) identified the role of fire in muskeg communities in the Canadian North; the importance of fire in Louisiana marshes was identified by Viosca (1928, 1931); Beaven and Oosting (1939) identified fire as a great agent of change in baldcypress swamps; Wells (1928, 1931) and Penfound and Hathaway (1938) recognized fire as important in southeastern United States pocosins and coastal marshes; and Bradbury (1938) listed fire as a marsh management tool that benefited wildlife while assisting mosquito control.

Despite appreciation among plant ecologists of the role of fire, early use of fire in wetlands management by land management agencies was apparently stymied by the mind-set of the majority of first-generation wildlands managers who viewed fire as an entirely negative phenomenon (Conway 1938; U.S. Forest Service Library 1938; Cox 1939; Hanson 1939). Fire as a natural occurrence, and as a practical tool for managing coastal marshes for furbearers, was generally appreciated by the public, however, and observation of general fire effects, versus scientific investigation per se, led wildlands managers to several basic conclusions on use of fire in wetlands by the 1940's. Wells (1942) and Garren (1943) identified fire as responsible for the development and maintenance of several wetland communities in the Southeast; Griffith (1941) and Smith (1942) described the value of burning in Atlantic coast marshes; Lay and O'Neil (1942) discussed the value of burning for muskrat management on the Texas Gulf coast; and Cartwright (1942) and Ward (1942) identified the value of burning in maintenance of the Delta Marsh, MB. Lynch (1941) described several "types" of burns in Gulf coast marshes, suggested their potential value in managing other types of marshes, and identified the need for further study of fire in marshes. Lynch's descriptions, embellished and repeated by later authors, became the litany of wetland fire managers, but there was no substantial response to his request for further studies of marsh burning for 20 years, until Hoffpauir's (1961*a*) thesis appeared as the first of a long series of quantitative studies of fire in the Louisiana marshes.

The frequency distribution of publication dates of literature addressing fire–wetlands relations (Table 2) documents the initially low, but steadily increasing, amount of interest in the subject into the 1980's. In the present decade, interest in investigating fire–wetlands relations has risen dramatically with the result that more than one-third of the papers in this bibliography have appeared since 1979. Since certain categories of fire–wetlands papers, namely limnological studies and most information from the Far North, were purposely limited in the annotated bibliography, the apparent approximately 100% increase in reported results per decade from the 1920's through the 1970's greatly understates the increase in the literature on fire in general and the sum of literature related to fire in all wetland ecosystems worldwide in particular. For example, Vierick and Schandelmeier (1980) listed approximately 750 references on the effects of fire in Alaska and adjacent Canada, a number 2.4 times larger than the material in this annotated bibliography. Detailed studies of fire in the North have increased dramatically since World War II, with the greatest increase in the most recent years.

The rate of increase of reports of fire–wetlands studies appears to be leveling off if the data available through July 1987 can be taken as an indication. Nonetheless, the number of studies is still increasing and a firm basis for much more detailed work has been developed in many parts of North America. As one indication of the "arrival" of fire–wetlands studies in the consciousness of land managers throughout North America, the number of texts and reviews that addressed fire–wetlands relationships grew dramatically in the 1970's and this demonstration of level of interest has been sustained. (Table 2).

The geographic distribution of studies of fire–wetlands relations (Table 3) only partially reflects the distribution of major wetlands in North America. Thus, one can recognize several areas of emphasis already addressed in fire–wetlands studies as well as other areas in

Table 2. *Frequency distribution of dates of publication of literature addressing fire–wetlands relationships included in the annotated bibliography (n = 319), 1923–1987.*

Year	Journal article or government document reporting on a single subject	Reviews, textbooks bibliographies	Theses, dissertations
1987	4	2	
86	5	3	2
85	19	3	2
84	14	2	
83	8	5	4
82	8	4	5
81	12	6	
80	5	2	1
79	14	8	2
78	7	3	
77	6	2	1
76	9	2	2
75	2		2
74	7	3	1
73	7	3	1
72	4		
71	4	3	1
70	1		1
69	6	2	1
68	5		2
67	3		3
66	3		1
65	1		
64	5	1	
63	2		
62	6	1	
61	2		1
60	2	1	
59	3		
58	2		
57	2		
56	1	1	
55	2		
54	1		1
53	3	1	
52	2	1	
51	4		
50	2		
49	3	1	
48			1
47	2		
46	1	1	
45	1		
44	1		
43	1	1	
42	5		
41	3		
40			
39	2	1	
38	4	1	
31	2	1	

Table 2. Continued

Year	Journal article or government document reporting on a single subject	Reviews, textbooks bibliographies	Theses, dissertations
28	3		
26	1		
24	1		
Totals	**223**	**61**	**35**

need of basic investigation. Within the Atlantic states and provinces, 27 of the 95 papers (28%) have addressed freshwater pocosins, bogs, Carolina bays, and canebrakes of the Coastal Plain. These increasingly rare communities are dependent upon fire to maintain a mixture of seral stages and currently remain the object of intense botanical and conservation interest. Two other large, well known wetlands on the Atlantic coast have also been the subject of substantial studies, specifically of the relation of fire to many aspects of ecosystem functioning. The Okefenokee Swamp of Georgia with 16 studies and the Great Dismal Swamp on the North Carolina–Virginia border with 6 studies have received some of the most sophisticated analyses in the East. A third area, the Pine Barrens of New Jersey, once known for extreme conflagrations, now is burned much less often and studies have concentrated on upland sites despite the great number of wetlands and surrounding coastal marsh in the Barrens. The five studies on the Pine Barrens are thus but a fraction of the literature on the area's relation to fire. As an indication of interest in these four major wetland ecosystems of the Atlantic states, each has been the subject of recent monographic treatment: pocosins (Richardson 1981; Sharitz and Gibbons 1982; Ash et al. 1985); Okefenokee Swamp (Cohen et al. 1984); Great Dismal Swamp (Kirk 1979); and the Pine Barrens (Forman 1979).

Studies from Georgia and North Carolina and those that address the entire mid-Atlantic and Southeastern region dominate the available publications on fire–wetlands relations in the eastern United States and Canada. These areas include the numerous previously mentioned Okefenokee and pocosin studies, but additional contributors to this geographic concentration of effort appear to be the long-standing interest by plant ecologists in the flora of the Atlantic Coastal Plain and substantial interest in economically efficient management of coastal marshes and eastern pine and lowland forests. In the latter cases, both industrial and wildlife management reasons have provided incentives for research on fire–wetlands relations.

Within Florida, 20 of the 32 studies (62%) have addressed the Everglades ecosystem or nearby natural areas. With increasing human pressure upon natural landscapes in southern Florida, and the ongoing research programs of the Everglades National Park and nearby preserves, substantial work on this system has ensued. Monographic treatment of the entire system includes Loveless (1959) and Duever et al. (1986). Cypress swamps and forested wetlands in general have been recent subjects of intense study because of their value to fish, wildlife, and water quality, and in some areas, their potential for treating wastewater. Cypress swamps have been covered in two recent monographs (Ewel and Odum 1984; Duever et al. 1986); Atlantic white-cedar swamps in two older reviews (Korstian and Brush 1931; Little 1950); and bottomland hardwood and other forested wetlands have been addressed by a number of Fish and Wildlife Service and other government publications (e.g., Wharton et al. 1982).

Table 3. *Study areas of 298 publications cited in the annotated bibliography on fire–wetlands relationships.* [1]

Location	Number of citations	
Wide Geographic Reviews		40
Far Northern Ecosystems		15
Alaska	4	
Boreal Forest/Taiga/Tundra	11	
Atlantic States and Provinces		95
Atlantic coast	5	
Georgia	22	
Labrador	2	
Maine	1	
Maryland	3	
Massachusetts	1	
Mid-Atlantic and Southeast	20	
New Brunswick	2	
New Jersey	5	
North Carolina	20	
North Carolina and Virginia	6	
Northeast	2	
South Carolina	5	
Quebec	2	
Virginia	1	
Florida		32
Gulf States		43
Gulf coast	5	
Alabama	2	
Louisiana	19	
Texas	11	
Mississippi	6	
Inland Midwest and Plains		59
General	6	
Colorado	1	
Iowa	3	
Manitoba	9	
Manitoba and Saskatchewan	1	
Michigan	3	
Minnesota	2	
Missouri	1	
Nebraska	1	
North Dakota	7	
Ontario	1	
Saskatchewan	2	
South Dakota	1	
Utah	9	
Wisconsin	12	

(Continued)

Table 3. Continued

Location	Number of citations	
Western U.S. and Canada		14
Alberta	4	
Arizona	2	
California	2	
Oregon	3	
Southwest	1	
Northwest	1	
Rocky Mountains	1	

[1] To remove redundancy, this Table does not include 21 theses and dissertations that resulted in publication of all or part of original data collected in the Eastern U.S. (1), Georgia (2), Florida (1), Louisiana (3), Maine (1), Manitoba (1), Mississippi (1), North Carolina (4), North Dakota (1), Oregon (1), Texas (4), and Utah (1).

In the Gulf states, almost all of the studies have addressed coastal areas, with emphasis being placed on the coastal prairies of Texas (26%) which have been of substantial interest to livestock producers as well as Louisiana salt and brackish marshes noted for their furbearer and waterfowl resources (44%). These latter marshes have been subject to manipulation for so long (200+ years) that management schemes are relatively straightforward, but recent coastal subsidence and loss of marsh threatens coastal Louisiana, suggesting the need for further studies.

The inland Midwest and Great Plains were only addressed by 20% of the papers despite the large area encompassed. The extensive inland wetlands of the interior thus seem severely understudied from the standpoint of their interaction with fire. Given their importance to migratory birds and resident wildlife, and their recently much diminished areal extent, experimentation with fire and and all other available management options seems imperative if the resource is to be sustained. The high number from Wisconsin includes numerous general studies, but also reflects concentration on management of Horicon Marsh. Six of the nine papers from Utah were by the same set of authors, and comprise detailed studies of the Great Salt Lake marshes. The prairie pothole country of the Dakotas, Minnesota, and the Canadian Prairies has received little concentrated study with the notable exception of the Delta Marsh, MB. The Delta Marshes were the site of early attempts to manipulate emergent marsh vegetation with fire (Ward 1942, 1968) and continue to be an important site for experimental studies of alternative marsh management strategies (Neckles et al. 1985; Thompson and Shay 1985; Shay et al. 1987).

There is no clear explanation for the lack of studies of fire–wetland relations in the West. The paucity of wetlands in many areas may be one factor, but continued interest in maintaining riparian zones suggests that studies addressing grazing, fire, and other range management practices are still needed. The effects of fire on high mountain wetlands appear completely unstudied, as does the effect of fire on Pacific coastal marshes.

The concentration of studies in relatively few geographic areas seems to be at least partially attributable to development of graduate programs emphasizing marsh ecology and fire at only a few universities. The geographic distribution of both study sites and issuing

institutions that confer degrees for studies of fire–wetlands relations (Table 4) shows the clear numerical superiority of Louisiana State University, and to a lesser extent, Texas A&M University, the University of Georgia, and Iowa State University. All four institutions have access to nearby State and Federal refuges and wildlife management areas, and have ongoing programs that integrate range, wildlife, and botanical studies. In general, however, the subject has not been addressed by student degree programs as often as we had expected, especially given recent emphasis at many universities on whole-ecosystem studies, successional relations in plant communities, and the flow of energy and cycling of nutrients in ecosystems. The most critical finding, however, was that 14 of the 35 theses and dissertations that addressed fire–wetlands relations apparently resulted in either no published manuscripts or published papers that did not discuss the fire–wetlands aspects of the research. Given the general difficulty of locating unpublished Masters theses, especially, it seems clear that those interested in site-specific studies will have to make personal inquiries to locate older, unpublished material.

The subject index shows that several major groups of organisms have received little attention with regard to fire. For example, studies of the effect of fire upon wetlands used for livestock range universally ignore the effects of burning upon ground-nesting nongame birds, reptiles, amphibians, and invertebrates. Invertebrates, as a group, have received almost no mention in the fire–wetlands literature although they have been addressed in studies of fire in upland sites. Fire in and adjacent to prairie wetlands has been assessed with regard to ground-nesting waterfowl, but the effects of fire on marsh and wading birds dependent upon cattails, common reed, bulrush, and other emergent aquatic plants for cover, food substrate, and nest sites have been barely mentioned. Only in studies of coastal marshes in Louisiana has enough data been collected to provide broad managment prescriptions. The conclusion from these Louisiana studies is that it is not possible to use fire to manage these coastal areas simultaneously to benefit livestock, waterfowl, muskrats, and other marsh wildlife. This suggests that use of fire in wetlands elsewhere should be for specific management purposes and not applied as a tool of supposed benefit to all marsh wildlife and plants.

Eighty-one (27%) of the entries in the annotated bibliography were reviews of broad geographic scope, or texts discussing numerous aspects of fire, habitat, or species management. As expected, there was much overlap in these review papers, since the original literature is so limited. Nonetheless, despite these reviews, no wetland management handbook exists that fully integrates fire management with other wetland management practices and that presents specific management guidelines. There is a need for such a synthesis, but as this bibliography makes clear, much is yet unknown about the use of fire in marsh management and the effects of fire on wetland ecosystems. Furthermore, the literature reviewed in this bibliography emphasizes more the uniqueness of each wetland system than the similarities of all wetlands in their responses to fire. This suggests that the entire field of study, except for those wetlands the subject of multidisciplinary research (Great Salt Lake marshes, Delta Marsh, Okefenokee Swamp, the Everglades, etc.), is still at the basic data-gathering stage for most of North America and that synthesis might occur more appropriately some time hence. Several areas in need of major inquiry can be defined. We particularly need data to develop fire prescriptions for various wetland types, further knowledge of the effects of fire upon marsh nutrient cycling, a better understanding of the use of fire in managing wetland complexes in the Great Plains, and development of optimal schemes to meet air and water quality objectives while simultaneously meeting wetland management objectives through appropriate use of fire.

Table 4. *Geographic distribution of issuing institutions and study areas of 35 theses and dissertations addressing fire–wetlands relationships included in the annotated bibliography.*

University (State)	N published	N unpublished	Degree	Study Area
Auburn (AL)		1	M.S.	Georgia
Colorado State		1	M.S.	Utah
Cornell (NY)	1		Ph.D.	Florida
Duke (NC)	2		Ph.D.	North Carolina
Florida State	1		Ph.D.	Eastern U.S.
Humboldt State (CA)		1	M.S.	Florida
Iowa State		1	M.S.	Iowa
		1	M.S.	Manitoba
	1		Ph.D.	North Dakota
Louisiana State	3	5	M.S.	Louisiana
North Carolina State	1		Ph.D.	North Carolina
Oregon State	1		Ph.D.	Oregon
Princeton (NJ)		1	Ph.D.	Maryland
Texas A&M	1		M.S.	Texas
	2		Ph.D.	Texas
	1		Ph.D.	North Dakota
Utah State	1		Ph.D.	Utah
Georgia	2	1	Ph.D.	Georgia
Maine	1		M.S.	Maine
Manitoba	1		M.S.	Manitoba
Miami (FL)		1	M.S.	Florida
Michigan		1	Ph.D.	Michigan
Southern Mississippi	1		M.S.	Mississippi
North Carolina	1		Ph.D.	North Carolina

Annotated Bibliography on Fire in Wetland Ecosystems

1. A. D. Revill Associates. 1978. Ecological effects of fire and its management in Canada's National Parks: a synthesis of the literature. Parks Canada, Ottawa, ON. 3 vols.

This multivolume work is a bibliography and review of the effects of fire in ecosystems, particularly those typical of or similar to Canada's National Parks. Volume I (191 pp.) provides a review of the literature in 10 chapters that cover fire's effects on all parts of the major ecosystems of Canada, the history of fire occurrence, and the current use of fire in resource management. Volume II (345 pp.) is an annotated bibliography of 446 references considered of greatest importance to fire issues in Canada. Volume III (unnumbered pages) contains 2,240 additional references regarding fire. This review, although emphasizing issues pertinent to Canada's National Parks, nonetheless provides an excellent compendium of the literature on North America's temperate and boreal forests, grasslands, and arctic tundra. Although wetlands are not discussed per se, the effects of fire on beaver, muskrats, and fish are discussed in detail as are the total effects of fire on the various ecosystems in which wetlands occur in Canada. [K–L–S]

2. Ahlgren, I. F., and C. E. Ahlgren. 1960. Ecological effects of forest fires. Bot. Rev. 26:483–533.

Apparent contradictions regarding the effect of fire on soil and living organisms are discussed. Each combination of region, climate, forest tree association, soil type, and plant species must be considered individually to draw proper conclusions. North American, as well as other literature is reviewed in detail. This paper provided a state-of-knowledge review through 1960. [K–L–S]

3. Alexander, T. R., and A. G. Crook. 1974. Recent vegetational changes in southern Florida. Pages 61–72 *in* P. J. Gleason, ed. Environments of south Florida: present and past. Miami Geol. Soc. Mem. 2.

Alterations imposed by man and fire in southern Florida have resulted in profound changes in the past 70 years. Shifts in species composition and replacement of entire communities can be recognized. Changes in graminoids, tree islands, mangrove, palmetto, cypress, pineland, hammocks, the Keys, farmed land, levees and roadsides, and exotic species are documented for a 16-30 year period. [K–L–S]

4. Allan, P. F. 1950. Ecological bases for land use planning in Gulf coast marshlands. J. Soil Water Conserv. 5:57–62, 85.

Uncontrolled burning causes retrogression of coastal marshes as does uncontrolled grazing. Burning a marsh every second spring to develop stands of Olney bulrush at the expense of marshhay cordgrass is, however, a principal means of marsh management for muskrats. Overgrazing of burned areas by muskrats and geese may lead to return of marshhay cordgrass, but deliberate overgrazing and intensive burning of coastal marsh may be required to maximize benefits for waterfowl. Fresh marshes can also be treated with grazing and fire to encourage plants beneficial to waterfowl. Simultaneous management for maximum benefit for muskrats, livestock, and waterfowl is not possible. [K–L–S]

5. Allan, P. F., and W. L. Anderson. 1955. More wildlife from our marshes and wetlands. Pages 589–596 *in* Water: The Yearbook of Agriculture 1955. USDA., Washington, DC.

The most important reason for burning marshes is to favor preferred plants and destroy those of little value. A secondary reason is to remove accumulated dead material. A clear view of intended results and selection of appropriate seasons and conditions for burning are important. Olney bulrush marshes should be burned every year except during drought. In the South, burn should be from mid-October to January; in the North in late winter but before young muskrats appear. Best results are obtained when several inches of water are on the marsh. Burning just prior to the spring growing season to control marshhay cordgrass is also the preferred management for saltmarsh bulrush. Fire can be used to burn deep holes in

peat to form ponds in any coastal marsh. In general, spring burns benefit waterfowl (versus fall-winter burns for muskrats). On inland marshes, fire should be used with care, perhaps only to remove dead vegetation and to kill invading trees and shrubs. [K–L–S]

6. Anderson, H. W. 1974. Fire effects on water supply, floods and sedimentation. Proc. Annu. Tall Timbers Fire Ecol. Conf. 14:249–260.

The effects of fire on water in the forest are variable. Light burning has little impact; major wildfires, however, have substantial impact on storms, erosion, sedimentation, and quantity of streamflow. The duration of effects is strongly affected by the rate of revegetation. Examples are provided of effects of various fire intensities. The major conclusion is that fire protection in recent years has reduced the hydrologic importance of fire. [K–L–S]

7. Anderson, P. B., and R. Best. 1982. Fire in Okefenokee Swamp: successional response of a young cypress community. Bull. Ecol. Soc. Am. 63:205. (Abstract only)

Periodic fires are a major mechanism influencing long-term dynamics of plant community succession in Okefenokee Swamp. After a 1981 fire in a young pondcypress wetland, three species (redroot and two sphagnum peat mosses) dominated recovery in the herbaceous layer. Most shrub stems in the burned area died; regrowth and recovery were limited to less severely burned portions. A significant number of trees survived, recovering through stump resprout or resprouting from the primary bole. [From authors' abstract]

8. Anderson, S. H., compiler. 1982. Effects of the 1976 Seney National Wildlife Refuge wildfire on wildlife and wildlife habitat. U.S. Fish Wildl. Serv., Resour. Publ. 146. 28 pp.

A 260 km^2 burn in the summer of 1976 resulted in an increase in wildlife species richness because the patchy nature of the fire created new habitat. Effects on vegetation, mammals, birds, reptiles, amphibians, fish, water quality, and soils were determined. Those species limited by lack of edge increased as did those that benefited from structural change in the habitat. No species were extirpated because no habitat was completely destroyed. Results emphasize that knowledge of the biotic community, its successional stage, and general climatic conditions at the site must be incorporated in planning for use of fire as a wildlife management tool. This study is a good example of the comprehensive approach necessary to fully assess the impacts of wildfires on refuge (and other) lands. [K–L–S]

9. Angell, R. F. 1983. Winter diet composition and quality, and performance of cattle grazing burned and unburned gulf cordgrass rangeland. Ph.D. Dissertation. Texas A&M University, College Station. 135 pp.

Following late fall burns, gulf cordgrass growth averaged 10 kg/ha/day but was greatly reduced during cold periods. Steer diets averaged 80% and 71% live leaf tissue on burned and unburned treatments, respectively. In 2 of 3 years, burning elevated the percentage of live leaf in diets over that of unburned plots. Because of lack of sufficient green forage on adjacent unburned uplands, cattle on both burned and unburned range consumed substantial gulf cordgrass. Cordgrass consumption decreased in March and April when more palatable forages became available. Burning increased steer diet quality and cattle on burned areas gained significantly more weight than cattle on unburned pastures. Diet quality will be enhanced during times of restricted gulf cordgrass growth if Texas wintergrass is available on adjacent upland areas. [From author's abstract]

10. Angell, R. F., J. W. Stuth, and D. L. Drawe. 1986. Diets and live-weight changes of cattle grazing fall burned gulf cordgrass. J. Range Manage. 39:233–236.

Burning increased dietary crude protein in Texas coast gulf cordgrass from January through March and increased in vitro organic matter digestibility during February and March. Cattle gained or maintained weight on burned pastures but maintained or lost weight on unburned pastures. Burned gulf cordgrass can provide alternative green forage when cool season species are absent. [From authors' abstract]

11. Ash, A. N., C. B. McDonald, E. S. Kane, and C.A. Pories. 1983. Natural and modified pocosins: literature synthesis and management options. U.S. Fish Wild. Serv., FWS/OBS-83/04. 156 pp.

Even in areas of low productivity, the high flammability of shrubs and peat soils virtually assures that pocosins will burn at relatively fraquent intervals (20–30 years). Most pocosin species are adapted to tolerate fires, and fire is the major factor promoting environmental and thus vegetative heterogeneity. Although fire and other disturbances may have created some pocosins from swamp forests, most extensive raised bogs (short pocosins) have not changed for several thousands of years. In transitional areas at the periphery of short pocosins, the importance of fire in maintaining pocosin vegetation increases greatly. Rather than creating pocosins, fire and juman disturbance have modified pocosin boundaries. Savannas—longleaf pine and grass communities growing on high spots without peat adjacent to pocosins—are palustrine wetlands maintained by frequent fire. Frequently burned savannas support perhaps the greatest species diversity of any plant community. Management of pocosins requires that natural fires proceed so song as life and property are adequately protected. Periodic controlled burning is a useful alternative to natural fires, but burning in and around pocosins requires careful planning. Burning of pine plantations or savannas adjacent to pocosins should be done in early spring under favorable conditions of wind, jumidity, and water table depth. The water table should be high enough to saturate peat and thus prevent low groung fires from entering the pocosin. Three– to five–year intervals are best for burning, but because extended drought may preclude burns, fire should be used in every year conditions are favorable. Fire in shrubby pocosins on peat sils can only be initiated after firebreads are constructed. Roads and canals may suffice, but may need to be improved. Favorable wind, jumidity, and water table conditions must be present. Impoundments in this habitat should also be burned as often as possible to improve wildlife food production, availability, and utilization, to control pest species, and to encourage preferred plants. A burning cycle of once per 5 years is acceptable. [K-L-S]

12. Auclair, A. N. D. 1977. Factors affecting tissue nutrient concentrations in a *Carex* meadow. Oecologia (Berl.) 28:233–246.

Principal components analysis of interrelations between tissue elements indicated a clear distinction between N, P, K, Cu, Mn, and Zn levels and ash, Ca, Mg, Na, and Fe levels on the first component. This difference related closely to water depth and fire frequency. Analysis of sedges, narrowleaf cattail, and the litter of this southern Quebec wetland suggested the loss of N, P, K, Cu, Mn, and Zn by volatilization, runoff, or leaching as shown by the coincidence of burning with water depth and the period of maximum snowmelt and runoff. [From author's abstract]

13. Auclair, A. N., A. Bouchard, and J. Pajaczkowski. 1973. Plant composition and species relationships on the Huntingdon Marsh, Quebec. Can. J. Bot. 51:1231–1247.

Emergent aquatic and sedge meadow communities were recognized. Disturbance related to chance perturbations, water depth, and the incidence of fire accounted for much of the variation in the sedge meadow community. Annual burning (presumably by local residents) maintains the meadows against invasion by shrubs, increases nutrient mineralization, and provides a pronounced change in albedo which permits earlier spring growth. [From authors' abstract]

14. Austin, D. F. 1976. Vegetation of southeastern Florida—I. Pine Jog. Fla. Sci. 39:230–235.

Frequent fires between the 1920's and 1946 decreased total floristic diversity in the Pine Jog ponded wet prairies. Invasion of cajeput tree and other exotic species has further changed these Florida wetlands. The entire Pine Jog region is undergoing secondary succession with wet prairies changing to pine flatwoods because of lowering of the water table by drainage. [K–L–S]

15. Babcock, K. M. 1967. The influence of water depth and salinity on wiregrass and saltmarsh grass. M.S. Thesis. Louisiana State University, Baton Rouge. 109 pp.

Wiregrass (marshhay cordgrass) and saltmarsh grass (seashore saltgrass) from burned and unburned areas were subjected to water depths of from 5 cm below to 53 cm above the soil surface and salinities from 1.47 ppt to 34.69 ppt. The best salinities for growth were from 5 ppt to 25 ppt. Both species decreased in density when water depths exceeded 30 cm on burned samples. Decrease also occurred in unburned samples, but to a lesser extent. Marshhay cordgrass and saltmarsh grass can be reduced by winter burning followed by immediate flooding with 30 cm of water which should be maintained until late spring. The control practices increased Olney bulrush, an excellent wildlife food. [K–L–S]

16. Baldwin, A. G. 1958. Burned: 12,000 acres—on purpose! Wis. Conserv. Bull. 23:18–19.

This brief, anecdotal account presents an overview of the use of fire as a tool for habitat management in Wisconsin. Periodic burning maintains sedge marshes as open areas useful to wildlife. Used with extreme care, fire perpetuates sphagnum bogs and the sphagnum moss industry. After burning, grass and sedge marshes provide a lush growth of early spring greenery for deer and small mammals. [K–L–S]

17. Ball, J. P. 1985. Marsh management by water level manipulation or other natural techniques: a community approach. Pages 261–277 *in* H. H. Prince and F. M. D'Itri, eds. Coastal wetlands. Lewis Publ., Inc. Chelsea, MI.

A community multi-species approach to marsh management will both minimize human conflicts and maximize benefits for most plants and animals in Great Lakes and other marshes. Natural techniques are particularly appropriate for this community approach. Alone or in conjunction with fire or muskrat activity (real or simulated by mowing), water level manipulation is an ideal way to manage marshes. Dikes can be used to create or restore marshes, but a community approach is required to maximize benefits for all species. Long-term, experimental, interdisciplinary studies are needed both to understand the natural dynamics that should be duplicated and to understand the effects of natural management techniques, many of which are indirect. [From author's abstract]

18. Bancroft, L. 1977. Natural fire in the Everglades. Pages 47–60 *in* Fire Management, Southern Region, Forest Service, and Cooperative Fire Protection, Southeastern Area, State and Private Forestry, Forest Service, sponsors. Fire by prescription symposium proceedings. 13–15 October 1976. Atlanta, GA.

A review of the history of the Everglades region, fire research in Everglades National Park, and recent fire management is presented. [K–L–S]

19. Barber, Y. M., Jr. 1952. Experimental control of *Juncus roemerianus* with herbicides in North Carolina. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 6. 6 pp.

Of eleven herbicides or combinations of herbicides tested on needle rush, only the isopropyl ester of 2,4-D produced an effective kill. Cost for broadcast spraying is difficult to justify, but spot spraying may be efficient. Burning of plots after spraying (during the following winter) improves subsequent plant growth of remaining debris. In impoundments without controlled water levels, control can be effected by burning, flooding, or other more economical means than herbicides. [K–L–S]

20. Barker, W. T. 1983. Manipulations of plant species composition, animal distribution, and herbage production by burning. Bull Ecol. Soc. Am. 64:110. (Abstract only)

A 56,658 ha southeastern North Dakota sandhill area characterized by typical sand dune topography supports a mixed-grass prairie community on the uplands, a tall-grass prairie community on the midsites, and a sedge meadow community in the lowlands. Most of the area is grazed using a three pasture deferred rotation grazing system. Without manipulation of lowlands, the lowlands are 10% utilized by livestock and the uplands are overutilized. Shrubs invade the lowlands under these conditions. Burning the lowlands and three year rotation increased lowland utilization to 50%-80%, reduced lowland shrub densities, and decreased overutilization of upland sites. [From author's abstract]

21. Bayley, S., and H. T. Odum. 1976. Simulation of interrelations of the Everglades marsh, peat, fire, water, and phosphorus. Ecol. Model. 2:169–188.

Some of the principal controlling factors affecting the Everglades marsh system including growth of grass, water levels, rain, transpiration, peat deposition, fire, phosphorus, and controlled inflow of water containing nutrients were combined in a simple model. Using published data, coefficients were estimated and the model was simulated for several regimes, for varying concentrations of nutrient in the inflows, and for varying access to fire. The resulting graphs resemble patterns reported from the Everglades, with some regimes producing regularly repeating patterns and frequent small fires and others producing erratic and widely fluctuating patterns of vegetation, flood, and fire. If this model is pertinent, a regular period of variation of water inflow and limited nutrients may be means for management of marshes for long-range stability. [From author's abstract]

22. Beaven, G. F., and H. J. Oosting. 1939. Pocomoke Swamp: a study of a cypress swamp on the eastern shore of Maryland. Bull. Torrey Bot. Club 6:367–389.

As a result of drainage, cutting, and a severe drought in 1931, fires burned for 6 months, destroying all vegetation and peat over a large area. The deeper burns are now totally without peat and have returned to hydrarch succession which should continue unless further drainage occurs. Species present in the deepest burn and surrounding areas are listed for this most northern of baldcypress swamps. [K–L–S]

23. Bendell, J. F. 1974. Effects of fire on birds and mammals. Pages 73–138 *in* T.T. Kozlowski and C.E. Ahlgren, eds. Fire and ecosystems. Academic Press, New York.

Immediate and long-term effects of fire on wildlife are reviewed. Included are discussions of changes in species composition and energy flow following fire, changes in density and overall abundance of wildlife following fire, and various case histories to support the major points presented. The evolution of birds and mammals in burnable habitat (including the effects of fire upon wildlife speciation as a result of fire) and adaptation of birds and mammals to flammable habitat are examined. With reference to wetlands, burning results in open water and encourages seed-bearing plants which are valuable waterfowl foods. [See also Lyon et al. (1978) for an update of this material.] [K–L–S]

24. Beule, J. D. 1979. Control and management of cattails in southeastern Wisconsin wetlands. Wis. Dep. Nat. Resour. Tech. Bull. 112. 40 pp.

Fire has been used on state-owned wildlife areas in Wisconsin to dispose of accumulated cattail debris, to set back succession of woody plants, and to increase accessibility of the marsh surface to birds. Burning is usually begun in late fall, after heavy frosts have killed and dried plant tops, and is extended into spring before returning birds begin using this cover for nesting. Burning does not actually control cattail because viable plant parts are normally buried in ice or frozen soils. Only in a dried-out marsh, where fire can reach the peat layer, will cattails be controlled. [K–L–S]

25. Bliss, L. C., and R. W. Wein. 1972. Plant community responses to disturbances in the Western Canadian Arctic. Can. J. Bot. 50:1097–1109.

Tundra fires destroy most of the aboveground plant cover and increase the depth of the soil active layer. Fire stimulates growth of sheathed cottonsedge and bluejoint reedgrass. Dwarf heath recovers rapidly through rhizomes; lichens and mosses showed no early recovery. The different plant community, topographic, soil, ground ice landscape units responded differently to the surface disturbances tested to date (fire, crude oil spill, seismic testing, road construction, vehicle movements). [From authors' abstract]

26. Bontrager, O. E., C. J. Scifres, and D. L. Drawe. 1977. Comparison of chemical and mechanical methods for controlling huisache. Proc. Annu. Meet. South. Weed Sci. Soc. 30:232. (Abstract only)

In a comparison of control methods for huisache on bottomland range (Texas coastal prairie), spraying with an oil:water emulsion of

herbicides or diesel oil alone, or burning, then treatment of individual plants with herbicides, were both twice as expensive as low energy grubbing. [From authors' abstract]

27. Bradbury, H. M. 1938. Mosquito control operations on tide marshes in Massachusetts and their effect on shore birds and waterfowl. J. Wildl. Manage. 2:49–52.

Burning was used to simulate mowing on Duxbury Marsh. Invertebrates were made available to birds and quicker evaporation of water after removal of shading grasses helped control mosquitoes. August burning in small interspersed patches appears to benefit migratory birds while also controlling mosquitoes. [K–L–S]

28. Bray, M. P. 1984. An evaluation of heron and egret marsh nesting habitat and possible effects of burning. Murrelet 65:57–59.

Burning used to improve waterfowl nesting habitat at Bear River Migratory Bird Refuge, UT, also destroys dead stems of hardstem bulrush, primary nesting habitat for herons and egrets. Because little is known of effects of disturbance on traditional colonial nesting sites, fire should be used with discretion, especially if alternative nest sites are limited. [K–L–S]

29. Britton, C. M., J. E. Cornely, and F. A. Sneva. 1980. Burning, haying, grazing, and non-use of flood meadow vegetation. Oreg. Agric. Exp. Stn. Spec. Rep. 586:7–9.

This study evaluated the response of meadow vegetation to burning, haying, grazing, and non-use on Malheur National Wildlife Refuge, OR. A plot burned in November produced the most herbage of any by the following July, with yield of 8,104 kg/ha (7,230 lb/acre). Although some plant mortality occurred, those plants remaining were larger and more productive. [K–L–S]

30. Brown, A. A., and K. P. Davis. 1973. Forest fire: control and use, second ed. McGraw Hill Book Co., New York. 686 pp.

This standard teaching tool for undergraduate and graduate fire management courses provides an overview of fire science and can serve as a guide to developing fire plans and training fire personnel. Examples are drawn largely from the United States, but some from Canada and Australia are also included. The effect of fire on wetlands is not addressed except indirectly as it applies to watershed management. It is emphasized, however, that bottomland hardwoods, swamps, and bogs do burn and often are fire–adapted communities. [K–L–S]

31. Buckley, J. L. 1958. Effects of fire on Alaskan wildlife. Pages 123–126 *in* Proceedings Society of American Foresters Meeting, 10–13 November 1958. Syracuse, NY.

Fire is the most important single factor influencing forest and tundra in most of Alaska. Fire removes insulation, lowers permafrost depths and thus the surface, affects subsurface drainage, and modifies water-holding capacity of soils. The general lowering of the water table as a result of fire is thus probably detrimental to waterfowl in Alaska because of the reduction in waterfowl habitat. Conversely, however, removal of woody vegetation by fire increases the attractiveness of an area to most waterfowl species, and early growth of plants in newly burned areas may permit earlier nesting. [K–L–S]

32. Buell, M. F., and R. L. Cain. 1943. The successional role of southern white cedar *Chamaecyparis thyoides* in southeastern North Carolina. Ecology 24:85–93.

Atlantic white-cedar in southeastern North Carolina is a pioneer forest community on open peat soils. Its dependence upon open soils in an area normally heavily vegetated makes the species dependent upon fire, the only natural clearing agent. This fire must occur at times of high water, however, or the Atlantic white-cedar seedbed is also burned. The mature Atlantic white-cedar forest is extremely susceptible to fire. If protected entirely from fire, Atlantic white-cedar will not persist, but will give way to the bog climax, a broadleaf forest of evergreen hardwoods. [From authors' abstract]

33. Burgess, H. H. 1969. Habitat management

on a mid-continent waterfowl refuge. J. Wildl. Manage. 33:843–847.

Management practices used to increase waterfowl use of Squaw Creek National Wildlife Refuge, MO, are described. Prescribed winter burning, summer grazing or haying, and fall flooding proved to be an excellent sequence for converting wet prairies into migratory waterfowl habitat. Fire removed overstory or altered plant succession prior to employment of the other techniques. [K–L–S]

34. Cartwright, B. W. 1942. Regulated burning as a marsh management technique. Trans. N. Am. Wildl. Conf. 7:257–263.

Spring fires are set in Manitoba marshes to burn stubble prior to seeding or summer fallowing and to facilitate muskrat trapping. Improved nesting cover also results, enhancing waterfowl production. Adverse effects of fires on breeding waterfowl are counteracted by: (1) obtaining cooperation from hay-claim owners and muskrat trappers; (2) appointing resident fire guardians to regulate hay-burns, supervise fire lane construction, and curtail illegal fires; and (3) completing burns prior to the start of duck nesting. [From author's abstract]

35. Chabreck, R. H. 1968. The relation of cattle and cattle grazing to marsh wildlife and plants in Louisiana. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 22:55–58.

The relation of cattle grazing to wildlife varies considerably, depending on the stocking rate, months of grazing, plants present, and the wildlife concerned. In general, geese, common snipe, rails, and nutria benefit, and ducks and muskrats are harmed. Complete dewatering harms all wildlife. Burning, a common range management practice, removes accumulations of plant debris and old growth mature vegetation. The resulting sprout growth of marshhay cordgrass provides excellent grazing and attracts geese. Spring and summer burns destroy nests and young, but properly timed burns are not harmful to most wildlife. [K–L–S]

36. Chabreck, R. H. 1976. Management of wetlands for wildlife habitat improvement. Pages 226–233 *in* M. Wiley, ed. Estuarine processes. Vol. I. Uses, stresses, and adaptation to the estuary. Academic Press, New York.

Burning has been widely used, but the value of most of the effort is questionable in many coastal marshes. Burning can remove dense stands of vegetation and attract geese to marshes, and it facilitates marsh access by hunters and trappers. Nutria and raccoons move from burned marsh, however, because of lack of cover. Burning can give Olney bulrush an earlier start during the growing season, permitting it to outcompete marshhay cordgrass, but burning alone will not maintain the species and should not be substituted for necessary water levels and salinities in the management of this vegetation or any other coastal species. [K–L–S]

37. Chabreck, R. H. 1981. Effect of burn date on regrowth rate of *Scirpus olneyi* and *Spartina patens*. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 35:201–210.

Olney bulrush and marshhay cordgrass were grown in mixed stands in containers (surface area: 900 cm^2) and burned during the fall and winter on six dates (8 and 23 October; 8 and 20 December; 6 and 20 February). Plants in 18 separate containers were burned on each date and 18 containers were left unburned as a control. Biweekly counts were made of the number of culms of each species per container from 5 October to 18 April. A positive linear relationship ($P < 0.05$) was noted between culm production of both species and minimum temperature following burns. However, the regrowth of Olney bulrush increased at a greater rate with increasing temperature than did marshhay cordgrass. Photoperiod (decreasing day length) reduced the regrowth rate of marshhay cordgrass. The mean density of Olney bulrush approached or equalled preburn densities by the fourth week following burns, but marshhay cordgrass did not approach the preburn density until the eighth week. The mean density of Olney bulrush per container was greatest throughout the study period in the Burn 1 group ($\overline{x}$ = 52.8) and declined gradually to Burn 6 ($\overline{x}$ = 21.8). However, the mean density of marshhay cordgrass increased 49.4% from the first three burn dates ($\overline{x}$ =21.8) to the last dates ($\overline{x}$ = 47.5). [From author's abstract]

38. Chandler, G. A., Jr. 1969. Short term effects of various control measures on undesirable vegetation in a salt and a fresh marsh. M.S. Thesis. Louisiana State University, Baton Rouge. 57 pp.

Tilling, burning, chemical, and various combinations of treatments were used to improve marshland on and adjacent to Rockefeller Refuge, LA, for wildlife and cattle. Burning and tilling in combination were most effective in reducing marshhay cordgrass in fresh marsh; tilling was most effective in producing desirable plants. Tilling in the salt marsh reduced both marshhay cordgrass and seashore saltgrass. The herbicide Tri-fen decreased the number of saltmarsh grass stems, but tilling plus Tri-fen was more successful. Burning increased the number of stems of saltgrass, but burning, in combination with tilling, decreased the number of saltgrass stems over either treatment used alone. No treatments in the salt marsh were successful in increasing the desired American bulrush. [K–L–S]

39. Christensen, N. L. 1977. Fire in southern forest ecosystems. Pages 17–24 *in* Fire Management, Southern Region, Forest Service, and Cooperative Fire Protection, Southeastern Area, State and Private Forestry, Forest Service, sponsors. Proceedings: fire by prescription symposium. 13-15 October 1976, Atlanta, GA.

The fire cycle in pocosins is considerably longer (10-30 yr) than in longleaf pine ecosystems, and fires typically consume tree crowns. Dense shrub cover makes seedling establishment unlikely in nonfire years. Pond pine is adapted to this regime in that it produces epicormic sprouts and has serotinous cones resulting in seed release primarily after fire. Fire has been a selective force in southern ecosystems to the extent that organisms are not just resistant to fire, they are dependent upon fire. Fire is a stabilizing force necessary for homeostasis in these ecosystems. Whether or not prescribed fire is a disturbing force in a community depends upon the extent to which the natural fire cycle in the ecosystem is mimicked. Although silvicultural management may require use of fire to diminish diversity and complexity, ecosystem preservation requires understanding the characteristics of fire for that system. [K–L–S]

40. Christensen, N. L. 1981. Fire regimes in southeastern ecosystems. Pages 112–136 *in* H. A. Mooney, T. M. Bonnicksen, N. L. Christensen, J. E. Lotan, and W. A. Reiners, tech. coords. Proceedings of the conference: fire regimes and ecosystem properties. 11-15 December 1978, Honolulu, HI. U.S. For. Serv. Gen. Tech Rep. WO–26.

Fire has significantly influenced the evolution of ecosystems throughout the Southeast, particularly in the Coastal Plain. In areas where fire occurrence is stochastic and fires are intense, vegetation response is similar to classical successional schemes. In areas of chronic, low intensity fires, fire may play an integral role in ecosystem stability. Frequent low intensity fires maintain savannas. Moist savannas protected from fire are invaded by shrubs typical of adjacent evergreen shrub bogs. The location and abruptness of the boundary between shrub bog and savanna is a function of fire. Grass–sedge bogs may form after intensive cutting of moist savannas and subsequent frequent fire. Intense fires during drought burn a depression in the peat which then remains perennially moist. Herbs grow rapidly in these depressions, and their combustible litter burns comparatively frequently. These sedge bogs may be maintained by this change in fire frequency. Shrub bogs (pocosins) are subject to intense fires, but vegetation quickly recovers and shrub composition after low intensity fires remains unchanged. After high intensity fires, some shrub succession occurs. Atlantic white-cedar forests are the product of low frequency, relatively high intensity fire regimes related probably to their marginally moist soil conditions. Too frequent fire converts such areas to shrub bogs; infrequent fires result in succession to hardwoods. Infrequent low intensity fires may increase cypress dominance in swamp forests with substantial deciduous species. In nutrient-poor areas, evergreen species will increase with fire. The vegetational outcome following fire in a swamp forest is dependent upon fire intensity and the level of the water table. A shallow burn would be revegetated by shrub bog which in the absence

of further fire would succeed to white-cedar swamp. A deep burn in an area of high water table may initiate a sedge bog which will be maintained indefinitely by frequent fire. Fires that remove substantial peat may lead to deciduous swamp forests. [K–L–S]

41. Christensen, N. L. 1985. Vegetation response to burning and clipping in a North Carolina coastal plain pocosin. Bull. Ecol. Soc. Am. 66:154–155. (Abstract only)

Reduction of phytomass by burning was compared with removal by clipping. Although individual species responded differently, the treated areas did not differ significantly after one growing season. After the second growing season, phytomass and leaf area index were significantly greater in the burned area. Thereafter, both measures declined significantly in the burned area but continued to increase steadily in the clipped area. Post-treatment changes in nutrients and microclimate are related to these observations. [From author's abstract]

42. Christensen, N. L., R. B. Burchell, A. Liggett, and E. L. Simms. 1981. The structure and development of pocosin vegetation. Pages 43–61 *in* C. J. Richardson, ed. Pocosin wetlands: an integrated analysis of coastal plain freshwater bogs in North Carolina. Proceedings of a conference held 3-4 January 1980, at the Duke University Marine Laboratory, Beaufort, NC, sponsored by Integrated Case Studies Program in Natural Resource Analysis of the Duke University School of Forestry and Environmental Studies and others.

Fire has been a prominent force in the evolution of most pocosin plants as evidenced by the production of serotinous cones by pond pine and the capacity to sprout from subterranean organs found in nearly all pocosin plants. Vegetational patterns within and among pocosins are discussed and fire effects on vegetation and environment are described. [From authors' abstract]

43. Clark, M. K., D. S. Lee, and J. B. Funderburg, Jr. 1985. The mammal fauna of Carolina bays, pocosins, and associated communities in North Carolina: an overview. Brimleyana 11:1–38.

During a 4-yr period, approximately 17,000 trap nights and 200 field days in 12 North Carolina habitat types produced specimens or signs of 40 species of mammals. Fires, storms, and man-related disturbances create a patchy mosaic of habitats that affects positively the density and diversity of mammals in pocosin communities. Management of extensive pocosin areas is desirable if mammal diversity is to be maintained. [From authors' abstract]

44. Cohen, A. D. 1974*a*. Evidence of fires in the ancient Everglades and swamps of southern Florida. Pages 213–218 *in* P. J. Gleason, ed. Environments of south Florida: present and past. Miami Geol. Soc. Mem. 2.

Cores extracted from peat reveal many charcoal-rich lenses at depth. Since these lenses cannot be traced from one peat core to another, the conclusion is that ancient fires were restricted to the more fire-prone communities, particulary sawgrass. (Fires maintain sawgrass communities, but may convert grass or sedge marshes to open water.) There are no reasons to believe the Everglades have historically sustained prolonged dry periods which would permit widespread burning of peat [From author's abstract]

45. Cohen, A. D. 1974*b*. Petrography and paleoecology of Holocene peats from the Okefenokee swamp–marsh complex of Georgia. J. Sediment. Petrol. 44:716–726.

Vegetational continuity of the largest marshes of the Okefenokee is probably related to a continuous, uniform rise in water table, the common occurrence of fires, and the consistently greater depths of peat in these regions. Fires played an important role in the history of peat development through not only destroying peat but also by changing the character of vegetation. Fire converts swamps to open marsh, but most forested swamps would benefit from burning through the regular removal of flammable understory. Only during times of extreme drought or change in drainage would both peat and the surface vegetation burn. Fire thus controls the source vegetation in swamps and changes the character of phytogenic sediments by complete oxidation (ashing) and production of charcoal, much affecting genesis of coal deposits. [K–L–S]

46. Cohen, A. D., D. J. Casagrande, M. J. Andrejko, and G. R. Best. 1984. The Okefenokee Swamp: its natural history, geology, and geochemistry. Wetland Surveys, Los Alamos, NM. 709 pp. + map.

This synthesis volume addresses Okefenokee history and archeology (5 papers); ecology (13 papers); biogeochemistry (9 papers); paleoecology (5 papers); geology and geomorphology (8 papers); vertebrates (Appendix checklist); vascular plants (Appendix checklist); and the overall vegetation of the Swamp (map). Many papers make reference to the pervasive influence of fire in the Swamp. Papers by Duever and Riopelle (1984), Hamilton (1984), and Izlar (1984) from the volume are included in this bibliography. [K–L–S]

47. Conway, R. C. 1938. Marsh burning. Wis. Conserv. Bull. 3:9–10.

A brief, anecdotal account of the effects of marsh fires in Wisconsin is presented. The general conclusions are that the degree to which these fires destroy game cover, food, and game itself depends upon the season, size of the fire, general condition of the marsh, and weather. Spring burns reduce waterfowl nesting success. [K–L–S]

48. Cooper, C. F. 1971. Effects of prescribed burning on the ecosystem. Pages 152–159 *in* USDA Forest Service. Prescribed burning symposium proceedings. Southeast. For. Exp. Stn., Asheville, NC.

This paper summarizes the symposium. With regard to water-related issues, the value of fire in reducing water retention and increasing streamflow is marginal. Sediment yields are high immediately after fire, especially on rugged terrain. In the Southeast, properly managed fire should not adversely affect water quantity or quality. Caution is urged in combining burning with nitrogen fertilization because of hazards to health of high levels of nitrate in ground water and surface runoff. [K–L–S]

49. Cornely, J. E., C. M. Britton, and F. A. Sneva. 1983. Manipulation of flood meadow vegetation and observations on small mammal populations. Prairie Nat. 15:16–22.

The effects of manipulating flood meadow vegetation at Malheur National Wildlife Refuge, OR, by burning, haying, and grazing were compared. Responses of small mammals, which comprise a portion of the raptor food base, were also monitored. Fall burning decreased accumulated litter and standing dead vegetation, resulting in the greatest subsequent vegetation yield and height of any treatment. Fire induced immediate reductions in small mammal numbers by altering habitat, but populations had recovered by the first post-burn growing season. [K–L–S]

50. Cox, J. R., and H. L. Morton. 1985. Aboveground biomass quantities and livestock production at big sacaton riparian areas in southeastern Arizona. Pages 305–309 *in* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Ffolliott, and R.H. Hamre, tech. coords. Riparian ecosystems and their management: reconciling conflicting uses (First North American Riparian Conference), 16-18 April 1985, Tucson, AZ. U.S. For. Serv. Gen. Tech. Rep. RM-120.

Two big sacaton grassland riparian sites were burned and mowed. Both treatments reduced green biomass production; stocking rates were only one-third as high as on untreated pastures. In earlier periods before channelization in the grasslands, burning was a viable management scheme because of the extended growing season of big sacaton in flooded areas. Now, conditions have changed to the point that burning is not always the best choice. Currently, the best short-term management for livestock is to decrease carrying capacity and increase daily gains by burning in late winter and grazing in spring–summer. The best long-term management of the resource, however, is to discontinue late winter burning and mowing and increase carrying capacity during the spring–summer grazing period. [K–L–S]

51. Cox, J. R., and H. L. Morton. 1986. Big sacaton (*Sporobolus wrightii*) riparian grassland management: annual winter burning, annual winter mowing, and spring–summer grazing. Appl. Agric. Res. 1:105–111.

Both burning and mowing reduced green biomass available for livestock consumption in spring–summer. Stocking rates for cattle were only one–third as high as on untreated range. Mean daily gains in 1981 and 1982 averaged 0.41 and 0.67 kg/day on untreated and treated pastures, respectively, but total gains per pasture were 512 kg and 235 kg on the untreated and treated pastures, respectively. Burning and mowing can enhance immediate livestock gains, but annual burning may destroy these riparian grasslands. [From authors' abstract]

52. Cox, W. T. 1939. Marsh firebreaks—a boon to wildlife. Am. For. 45:109–111, 137.

Deep peat lands in northern Minnesota have been damaged by drainage and subsequent fire. These have been returned to more natural conditions by resettling farmers and building dams to raise water levels to control fire. Fire, originally uncommon, is once again largely absent from the area. [K–L–S]

53. Cross, D. H. 1983. Wildlife habitat improvement by control of *Phragmites communis* with fire and herbicides. M.S. Thesis. Colorado State University, Fort Collins. 81 pp.

Six burns were conducted at 14-day intervals from June to August 1981 at Fish Springs National Wildlife Refuge, UT. Three burned subplots were treated with Dalapon; one was not sprayed. Three replicates of each treatment were compared with three control sites. Effects of both burn and spray were most visible in the growing season following treatment. The value of fire was found to be limited to short-term, annual efforts in early spring to open dense stands for nesting waterfowl. Burns in July and August, with herbicide spraying at least 48 days later, can most significantly reduce common reed vigor as measured by height and density of stems. [From author's abstract]

54. Cypert, E. 1961. The effects of fires in the Okefenokee Swamp in 1954 and 1955. Am. Midl. Nat. 66:485–503.

During an extended drought, five major fires occurred in the Okefenokee Swamp of Georgia and Florida. More than 128,695 ha (318,000 acres) of the swamp and 56,658 ha (140,000 acres) of adjacent upland were burned. There was considerable destruction of pine timber on the upland, and some damage to the baldcypress and swamp tupelo forests within the swamp where pockets of peat were burned out. But the belief that the whole character of the swamp had been altered was erroneous; most of the area was only lightly or moderately burned. Coppice growth rapidly replaced the timber which was killed in the more severely burned areas. The number of river otters, raccoons, snakes, and most fish was drastically reduced during the drought. American alligators, sandhill cranes, herons, waterfowl, and black bears were not adversely affected; some of these may have actually been favored. Recurrent droughts and fires have long played an important part in the ecology of the swamp as is evidenced by charred stumps embedded in the peat and by charcoal deposits several feet below the surface. [From author's abstract]

55. Cypert, E. 1973. Plant succession on burned areas in Okefenokee Swamp following the fires of 1954 and 1955. Proc. Tall Timbers Fire Ecol. Conf. 12:199–217.

The three areas severely burned in 1954 and 1955 are all returning to swamp forest. Coppice growth rapidly replaces trees if the root systems are not killed by fire, even when shallow layers of peat are also burned. It thus seems that extremely severe or repeated fires are necessary to develop Okefenokee prairies (marshes). Fire appears responsible for the mosaic of habitats in the swamp. Either total exclusion of fire or completely uncontrolled fire would be detrimental to swamp wildlife. [K–L–S]

56. Daiber, F. C. 1974. Salt marsh plants and future coastal salt marshes in relation to animals. Pages 475–508 *in* R. J. Reimold and W. H. Queens, eds. Ecology of halophytes. Academic Press, New York.

The use of fire in coastal marsh management is described as a means to remove dead vegetation, re-establish lower successional stages, or return the marsh to an early hydric community. Fire prevents accumulation of organic matter and thus impedes elevation of the marsh and succession to upland communities. Summer burns will remove less palatable plants and thus attract cattle, and

provide fodder for geese which will compete with cattle. Muskrats can be driven from marshes by fire if it destroys houses and building material. Spring burning is best for muskrats. Any habitat management will alter the structure of the ecological community. In general, burning develops landscape and vegetation more suitable for wildlife. Proper choice of season and water conditions will prevent damage to the marsh during burning and will maximize benefits from the practice. [K–L–S]

57. Davison, V. E., and W. W. Neely. 1959. Managing farm fields, wetlands, and waters for wild ducks in the South. USDA Farmers' Bull. 2144. 14 pp.

Information on planting duck foods, converting marshlands to moist soil units, and planning best management practices for marshes, freshwater impoundments, brackish ponds, and bottomland hardwoods is provided. Burning is emphasized as a management tool to control undesirable plants, remove rough, and stimulate growth of species favored by geese, ducks, and muskrats. [K–L–S]

58. de la Cruz, A. A., and C. T. Hackney. 1981. The effects of winter fire and harvest on the vegetational structure and productivity of two tidal marsh communities in Mississippi. Mississippi-Alabama Sea Grant Consortium Publ. No. M-ASGP-80-013, Ocean Springs, MS. 115 pp.

Winter burning and harvesting (clipping to simulate haying) of needle rush marsh increased primary productivity of vascular vegetation by 21% to 48% during the following growing season. In big cordgrass marsh, primary productivity of treated plots not only increased by 12% to 24% over controls but also maintained higher productivity after two or three successive annual winter fires. Neither burning nor harvesting affected needle rush density, but height of plants decreased in harvested plots. Early flowering and greater number of culms with inflorescences also occurred in plots which received winter burning and harvesting. Minor plant species increased their biomass in the needle rush marsh for 2 to 3 consecutive years, presumably because of elimination of the restrictive canopy. Caloric and elemental constituents of both above- and below-ground tissues did not show seasonal patterns or clear-cut trends among treatment plots or between treatments and controls. [From authors' abstract]

59. Diiro, B. W. 1982. Effects of burning and mowing on seasonal whitetop ponds in southern Manitoba. M.S. Thesis. Iowa State University, Ames. 48 pp.

Mowing, spring burning, and fall burning were evaluated as management techniques for whitetop rivergrass. Water depth, temperature, and nutrient levels; invertebrate abundance and community composition; vegetative cover and production; waterfowl use; and simulated waterfowl nest successs were studied under different treatment regimes. Burning increases production of whitetop rivergrass but only if conducted on appropriate sites. In this study, fall-burned ponds had reduced water levels the following spring and reduced wildlife values in winter and summer; spring-burned ponds had no increase in whitetop production. Since whitetop must be reflooded after burning to increase production, fall burning of shallow ponds and most spring burning seems unjustified. If burning is used to manage whitetop rivergrass, it should be conducted in the fall and only on areas that do not rely solely on snow trapped within the basin as a water source. Areas with water level control should be burned in the fall and subsequently reflooded the following spring to maximize whitetop production. [K–L–S]

60. Doren, R. F., and R. M. Rochefort. 1984. Summary of fires in Everglades National Park and Big Cypress National Preserve, 1981. S. Fla. Res. Cent. Tech. Rep. SFRC-84/01. 58 pp.

Everglades National Park and Big Cypress 1981 fire records are summarized. Correlations of monthly fire frequencies, locations, and average size with ground water patterns, visitor use patterns, and lightning activity levels are presented. [From authors' abstract]

61. Dow, D. D., and A. L. Frick. 1987. Impact of coastal wetland loss and burning on net aboveground primary production at Grand

Bayou, LA. Bull. Ecol. Soc. Am. 68:294. (Abstract only)

The estimated annual net aboveground primary production loss of marsh macrophytes due to controlled burning between 1978 and 1985 was comparable to the annual loss in production accompanying land loss: 6 x 10^6 kg carbon/year. [From authors' abstract]

62. Duever, M. J., J. E. Carlson, J. F. Meeder, L. C. Duever, L. H. Gunderson, L. A. Riopelle, T. R. Alexander, R. L. Myers, and D. P. Spangler. 1986. The Big Cypress National Preserve, 2nd printing. Nat. Audubon Soc. Res. Rep. 8. 455 pp.

This monograph reviews all aspects of the ecology of Big Cypress National Preserve through July 1979. Historic and present fire patterns; the effects of fire upon plants, animals, and the atmosphere; fire management; prescribed burning; wildfires; fire prevention; and coordination of fire programs are addressed. Fire has been an important factor in the evolution and maintenance of Preserve vegetation. The greatest number of fires are in the mixed grass fuel type found mostly in the marshes and wet prairies. If fire burns to rock or mineral soil, the elevation of the site, its hydroperiod, soil type, and thus its vegetation are drastically altered. Fires are not common in undrained swamps, but cypress swamps are fire-adapted ecosystems that require a low but regular fire frequency to prevent succession to mixed swamp forests and eventually hydric hammocks. Cypress may not regain vigor for years following a fire, but they are deep-rooted and coppice readily, so are not destroyed except by deep muck fires. Logged cypress communities become monospecific coastal plain willow or Carolina ash forests after severe fire. Fire is a regular occurrence in prairies, marshes, and sloughs and prevents invasion of trees and shrubs, but little else is known of fire effects in these habitats with the exception of the sawgrass marshes characteristic of the Everglades. Mangroves burn rarely, but can recover from fire. Little is known of fire in salt marshes. [K–L–S]

63. Duever, M. J., J. F. Meeder, and L. C. Duever. 1984. Ecosystems of the Big Cypress Swamp. Pages 294–303 *in* K.C. Ewel and H.T. Odum, eds. Cypress swamps, University Presses of Florida, Gainesville.

Hydroperiod and fire frequency determine the distribution of plant communities in Big Cypress Swamp. Cypress dominated "strands" and "domes" occur in elongate and circular depressions, respectively, with scattered small ponds in the deepest areas and open dwarf cypress forest and fire-maintained marshes in intermediate elevations. Fire, hydrology, and exotic species are important management considerations for this area. [From authors' abstract]

64. Duever, M. J., and L. A. Riopelle. 1983. Successional sequences and rates on tree islands in the Okefenokee Swamp. Am. Midl. Nat. 110:186–193.

Establishment dates of woody species on islands undergoing primary succession differed from those undergoing secondary succession following fire. The appearance of a species in the sere was related to its light requirements, tolerance of periodic inundation, and ability to resprout following disturbance. Fire is the most likely factor to set back successional sequences in the swamp. Minimum ages of plant communities on each site can be estimated from the maximum age of each species on a tree island and knowledge of when each species enters the sere. [From authors' abstract]

65. Duever, M. J., and L. A. Riopelle. 1984. Successional patterns and rates on Okefenokee Swamp tree islands. Pages 112–131 *in* A. D. Cohen, D. J. Casagrande, M. J. Andrejko, and G. R. Best, eds. The Okefenokee Swamp: its natural history, geology, and geochemistry. Wetland Surveys, Los Alamos, NM.

(See Duever and Riopelle 1983)

66. Egler, F. E. 1952. Southeast saline Everglades vegetation, Florida, and its management. Vegetatio 3:213–265.

The southeast saline Everglades is a distinct geographical area, wholly within Dade County, Florida. The present vegetation complex appears to be a "fossil" phenomenon developed

under past conditions of higher water tables and Indian fires. Surface drainage has now been interfered with, subsoil salinity has increased, and fires are frequent and catastrophic. Maintenance of the seven vegetation belts of this area will require unprecendented manipulation of water, fire, and other factors. Differences between "Indian" and "whiteman" fires are discussed. Vegetation originally dependent upon fire for origination and maintenance is now being destroyed by fires in the wrong season and with too great intensity. [K–L–S]

67. Eleuterius, L. N. 1968. Floristics and ecology of coastal bogs in Mississippi. M.S. Thesis. University of Southern Mississippi, Hattiesburg. 186 pp.

(See Eleuterius and Jones 1969)

68. Eleuterius, L. N., and S. B. Jones, Jr. 1969. A floristic and ecological study of pitcher plant bogs in south Mississippi. Rhodora 71:29–34.

A peaty bog which had burned annually in the winter for the past 7 years was compared with a similar bog that had not burned for 3 years. Results suggest that pale pitcher plant and a number of native bog orchids are dependent upon fire to maintain the open bog. Fire retards succession toward "sedge-woody" species. Plant diversity overall was greater in the burned bog, as was plant productivity. [K–L–S]

69. Ermacoff, N. 1969. Marsh and habitat management practices at the Mendota Wildlife Area. Calif. Dep. Fish Game, Game Manage. Leafl. 12. 11 pp.

Undesirable winter emergents are controlled by cultivation, winter flooding, and burning. Late April and May burns produce the best results and favor germination of volunteer barnyardgrass and smartweed. A slow, concentrated fire moving into the wind is preferred. Drip torches can start the fire in heavy stubble; liquid petroleum weed burners can be used where stubble is sparse. Cost to burn is about $3.70/ha, about one-half the cost of discing. Cattails are disced, shredded, or mowed after June when the plants are in bloom and the ground is dry. (If this operation is performed earlier, it should be repeated in July or August.) Cattail stalks are allowed to dry then are burned. Reflooding after early October when the cattails are dormant and maintenance of 30 cm of water for 4 months completes effective cattail control. [K–L–S]

70. Ewel, K. C. 1984. Effects of fire and waste water on understory vegetation in cypress domes. Pages 119–126 *in* K. C. Ewel and H. T. Odum, eds. Cypress Swamps. University Presses of Florida, Gainesville.

Disposal of secondarily treated wastewater in two cypress domes near Gainesville, FL, led to formation and persistence of duckweed. Wastewater disposal and fire were associated with an increase in dominance of other herbaceous species. Although shrubs and other normal understory species remained common, fire increased both the dominance of herbaceous species and overall productivity by opening the canopy. The combined effects of wastewater and fire are greater than the effect of either perturbation alone. [From author's abstract]

71. Ewel, K. C., and W. J. Mitsch. 1978. The effects of fire on species composition in cypress ecosystems. Fla. Sci. 41:25–31.

Baldcypress trees were more successful than slash pines and hardwoods (swamp tupelo, sweetgum, sweetbay) in surviving a fire which destroyed 42% of two Florida dome ecosystems. Changes in percent of live trees within the domes before and after the fire die-off were 48 to 89 for baldcypress, 32 to 9 for hardwoods, and 21 to 2 for pines. Greatest mortality was in the dome center where organic matter was deepest. [K–L–S]

72. Ewel, K. C., and H. T. Odum, editors. 1984. Cypress swamps. University Presses of Florida, Gainesville. 472 pp.

In 3 chapters, this text reviews ecological patterns in cypress swamps (6 papers); effects of wastewater on cypress domes (19 papers); and structure and function of other swamps in eastern North America (15 papers).Three papers that provided details on the effects of fire upon cypress swamps (Duever et al. 1984; Ewell 1984; Gunderson 1984) are included in

this bibliography. The final paper in the text provides a synthesis of the regional role of cypress ecosystems. [K–L–S]

73. Faulkner, S. P., and A. A. de la Cruz. 1982. Nutrient mobilization following winter fires in an irregularly flooded marsh. J. Environ. Qual. 11:129–133.

The effect of prescribed winter burning on nutrient pools in an irregularly flooded marsh in St. Louis Bay, MS, were evaluated by assessment of prefire and postfire growth, prefire and postfire sediments, combustion residues, and reference material from unburned controls. Transitory elevation of sediment-water pH, P, K, Ca, and Mg occurred in the soil, but input to the marsh soils was minimal. Estimated losses of N and K from combustible plant matter exceeded 90% and 50%, respectively, in needle rush and giant cordgrass communities. Losses of these elements in standing elemental pools amounted to 70% for N and 40% for K in both communities. Elemental standing stock and absolute elemental concentration increased in spring regrowth, particularly with respect to N, and appeared associated with burning. Slight increase in sediment nutrients, increased sediment warming, and increased insolation may have contributed to this increase, but a slight lag in physiological ages of plants in burned sites may account for observed differences. [From authors' abstract]

74. Folk, R. H., III, and C. W. Bates. 1982. An evaluation of wildlife mortality resulting from aerial ignition prescribed burning. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 36:643–646.

Aerial ignition (from helicopters) of 90 ha of pine, pine-hardwood, and hardwood drains and ponds in the lower South Carolina Coastal Plain was evaluated for mortality attributable to the simultaneous burning of the entire tract. Many representatives of several species were observed both before and after the burn, but only one vertebrate, an eastern mud turtle which was unable to burrow into hard ground when overtaken by the flames, was found dead. Based upon the conclusion that the wildlife population of the area was typical, it was concluded that properly executed aerial ignition burns on the Coastal Plain do not cause significant direct mortality of wildlife. [K–L–S]

75. Folweiler, A. D., and A. A. Brown. 1946. Fire in the forests of the United States. John S. Swift Co., New York. 189 pp.

Two hundred fifteen references are discussed in detail under 14 chapters covering all aspects of fire effects and fire control. Although fire effects on wetlands are not specifically described, all effects on wildlife, including many species now known to be adapted to the early seral stages maintained by fire, are listed as negative. The text summarizes viewpoints of the time, many of which were disproven by research beginning in the mid-1970's. [K–L–S]

76. Forman, R. T., editor 1979. Pine Barrens: ecosystem and landscape. Academic Press, New York. 601 pp.

All aspects of the ecology of the New Jersey Pine Barrens are explored in 33 chapters that address people and their historical and recent effects; geology and soils; climate, water, and aquatic systems; vegetation patterns; flora and fauna; and ecological research opportunities and the uniqueness and complexity of the ecosystem. Almost all chapters address the effects of recurrent fire upon the Barrens and stress the importance of natural fire patterns to the maintenance of the Barrens vegetation. The chapter by Little (1979) that addresses fire's effects upon wetlands is included in this bibliography. [K–L–S]

77. Forman, R. T., and R.E. Boernes. 1981. Fire frequency and the pine barrens of New Jersey. Bull. Torrey Bot. Club 108:34–50.

Although the number of annual wildfires has remained at about 1,100 since 1940 when fire control became effective in the Barrens, the total area burned annually has decreased from 22,000 ha during 1906–1939 to 8,000 ha in the past 4 decades. The Pine Barrens are a mosaic of fire-caused patches at a fine-grained scale of small (average 6 ha) young patches within a coarse-grain scale of large (several tens of ha) variable size patches more than 4 decades old. The drop in point fire frequency (65 years now versus 20 years earlier in the century) favors nonfire-adapted populations, hardwood swamp

replacing Atlantic white-cedar swamp, and loss of the coarse-grained landscape mosaic. [From authors' abstract]

78. Forthman, C. A. 1973. The effects of prescribed burning on sawgrass *Cladium jamaicense* Crantz, in south Florida. M.S. Thesis. University of Miami, Coral Gables, FL. 83 pp.

The highest temperatures measured in a sawgrass fire occurred at 0.5 m above water in the greatest litter accumulation. Burning over water or wet soil resulted in no observable direct kill of sawgrass culms. Growth rates of leaves appear greater for about one month after burning than at other times with the exception of the usual seasonal surge from April through June. Fall-burned sites did not reach pre-burn height in the first year following burn; spring-burned sites did. The spring-burned sites had greater over-all growth rates than fall-burned sites. There were no changes in successional stage of the sawgrass community after fire although herbs initially increased. Large amounts of nutrients were released by the burns, but most were reduced and removed within 6 h. Sawgrass appears capable of withstanding repeated annual spring burning if the soil is moist, but effects upon flowering are unknown. [From author's abstract]

79. Foster, D.R. 1984. The dynamics of sphagnum in forest and peatland communities in southeastern Labrador, Canada. Arctic 37:133–140.

Long fire rotation, high levels of precipitation, and acidic nature of bedrock are factors contributing to the dominance of peat moss. In uplands, the successional sequence following fire often culminates in a carpet of peat moss (*Sphagnum girgensohnii*) overgrowing feather mosses (red-stemmed feathermoss, plume moss, and mountain fern moss). Fire burns selectively along ridges and hummock tops, among lichens, ericaceous shrubs, and conifers and their litter, leaving moister hollows unburned. On bog hummocks following fire or changes in moisture regime, peat moss (*Sphagnum fuscum*) overtops Cladonia lichens to provide a pronounced reference horizon. Fire is a locally important factor, but climate is also responsible for the observed stratigraphic sequences. [From author's abstract]

80. Foster, D. R., and P. H. Glaser. 1986. The raised bogs of southeastern Labrador, Canada: classification, distribution, vegetation and recent dynamics. J. Ecol. 74:47–71.

Lightning fires are an important environmental factor in southeastern Labrador. Fires spread easily from adjoining uplands through the shrubby and woody margins of raised mires. On the bog proper, fire burns preferentially along lichen-covered ridges and hummocks, eliminating lichen cover and killing conifers and aboveground portions of other vascular species. Peat moss is apparently killed by heat and there is little removal of peat or production of charcoal. Shrubs sprout prolifically after fire, and the charred humus becomes covered by lichens. With the exception of black crowberry, black spruce, and tamarack larch, which are killed by fire, the vascular species resprout to approximately their original cover within 20 years. [K–L–S]

81. Fox, K. M. 1969. Prescribed fire as a tool for increasing water yield. Pages 66–68 *in* R.F. Wogle, ed. Proceedings of the symposium on fire ecology and the control and use of fire in wild land management. 19 April 1969. University of Arizona, Tucson. [J. Ariz. Acad. Sci.]

Use of fire to decrease brush and other vegetation in the Southwest so as to increase watershed yield is described and proposed as a useful management tool. [K–L–S]

82. Fritzell, E. K. 1975. Effects of agricultural burning on nesting waterfowl. Can. Field-Nat. 89:21–27.

Agricultural burning in an intensively farmed region within Manitoba's pothole district is shown to affect the nesting activities of ground nesting ducks. All species except blue-winged teal preferred unburned nest cover, although success was higher in burned areas, where predators may have exerted less influence. Attitudes of farmers, burning chronology, and nest destruction by fires are also reported. [From author's abstract]

83. Furniss, O. C. 1938. The 1937 waterfowl season in the Prince Albert District, central Saskatchewan. Wilson Bull. 50:17–27.

Furniss was among the first to propose a benefit to waterfowl of marsh burning: American crow predation appeared less efficient in burned, and thus more open, stands of softstem bulrush and common cattail which normally permit the predators to walk and climb about within the nesting cover. [K–L–S]

84. Garren, K. H. 1943. Effects of fire on vegetation of the southeastern United States. Bot. Rev. 9:617–654.

Fire is as important an agent as climate and soil in determining the persistence of vegetation types in many parts of the Southeast. The effects of fire are reviewed for longleaf-slash pine, coastal plain and bottomland hardwoods, coastal plain swamp, and other upland forests as well as natural or artificial unforested areas. Regarding wetlands and fire, it is noted that pocosins can regenerate after wet season fires, but that otherwise there are various successional changes. Cypress swamps sometimes are little affected by fire. At other times, they change to shrubs. There are instances of cypress-tupelo swamps forming in fire-protected longleaf pine areas. Atlantic white-cedar swamps usually are completely destroyed by fire. Only if enough seed remains will the type regenerate. Regeneration, if it occurs, results in an extremely dense stand. In Louisiana, fire sets back succession of coastal marsh, and revegetation is retarded because of excessive leaching of ashes. The season of burning affects the impact of fire on coastal and swamp marshes. Fire appears responsible for the origin and maintenance of most southeastern grass-sedge bogs or "savannahs." [K–L–S]

85. Givens, L. S. 1962. Use of fire on southeastern wildlife refuges Proc. Annu. Tall Timbers Fire Ecol. Conf. 1:121–126.

Prescribed burning is very effective in conditioning upland wildlife and marsh habitat on many southeastern National Wildlife Refuges. It removes dense vegetation (e.g., cattail, cordgrass, and giant southern-wildrice) and accumulated litter. This makes valuable seed-bearing food plants, such as barnyardgrass and foxtail, more available to waterfowl. Burning also provides succulent sprout growth for browsing waterfowl (e.g., Canada geese). By setting back succession, more productive plant communities can be maintained. As a management tool, fire is most useful when used in conjunction with flooding and discing. Burning should be done in winter to minimize damage to bird nests. Examples are given of how fire has been beneficial on specific refuges. [K–L–S]

86. Givnish, T. J. 1981. Serotiny, geography, and fire in the pine barrens of New Jersey. Evolution 35:101–123.

Contrary to earlier suggestions, local fire frequency plays a predominant role in setting local levels of serotiny in pitch pine. Although gene flow from the Pine Plains, an area of fire-swept pygmy forests with a high incidence of serotiny, is not important in setting the frequency of serotiny in other Barrens areas more than 3–5 km away, significant differentiation occurs between frequently burned upland sites and rarely burned lowland sites less than 100 m apart. Synergistic effects of fire, soil, and physiography on serotiny are emphasized. [From author's abstract]

87. Glasser, J. E. 1985. Successional trends on tree islands in the Okefenokee Swamp as determined by interspecific association analysis. Am. Midl. Nat. 113:287–293.

Marshes ("prairies") of either aquatic or emergent hydrophytes are the earliest seral stage and occur in areas of severe or frequent burns in Okefenokee Swamp. Marsh formation requires that existing woody vegetation be killed by single fires that burn deeply enough to kill roots or by recurring fires that exhaust the regenerative capabilities of surviving roots, and that the peat surface be burned away to permit an increase in water depth. Succession of marshes to forested wetlands is accelerated by the formation of floating and attached peat islands that provide a substrate for tree and shrub invasion. Species diversity increases with island age and time since last disturbance. Fire history, seed dispersal, and island age appeared to be the major factors determining the species present on islands. [K–L–S]

88. Glover, F. A. 1956 Nesting and production of the blue-winged teal in northwest Iowa. J. Wildl. Manage. 20:28–46.

A 3-year study developed methods to estimate yearly production, identified population trends and factors affecting production, and developed management recommendations for northwest Iowa. Three unplanned fires destroyed nesting cover in large tracts. Blue-winged teal did not nest in the burned areas, even when the vegetation recovered rapidly. The detrimental effects of burning were reflected in teal populations as much as a year after the fire. [From author's abstract]

89. Goodwin, T. M. 1979. Waterfowl management practices employed in Florida and their effectiveness on native and migratory waterfowl populations. Fla. Sci. 42:123–129.

Fifteen of Florida's waterfowl management areas were evaluated regarding means to increase their attractiveness to waterfowl and thus augment waterfowl populations in the State. Burning was employed on nine of the areas assessed, and is generally agreed to be useful, along with grazing, to reduce coarse, perennial marsh plants and create favorable conditions for growing natural duck foods. Burning every second year maintains open water by eliminating debris. Lack of statewide intensive management is emphasized, and some potential solutions are presented. [K–L–S]

90. Gorenzel, W. P., R. A. Ryder, and C. E. Braun. 1981. American coot response to habitat change on a Colorado marsh. Southwest. Nat. 26:59–65.

The response of American coot to habitat alteration, including partial and complete drawdown, burning and reflooding, and complete removal of emergents, was studied on a Colorado marsh. Burning of segments of the emergent zone was done in March and April following the lowering of water levels by 30 cm. Burning failed to kill any emergents, but did clear litter from the previous year's growth. Use of the marsh during spring migration was not affected until low water levels exposed emergents. Number of nests decreased from 77 to 6 following alteration, but increased to 56 after reflooding. Alteration also resulted in a delay of 5 to 6 weeks in nesting and movement by coots from and to the marsh in response to loss or gain in preferred foods. Increases in aquatic foods after alteration extended fall migration use. Coot populations can be managed easily through habitat manipulation. Activities such as water manipulations, burning, or dredging should be restricted to periods of coot absences. [From authors' abstract]

91. Grange, W. B. 1949. The way to game abundance. Charles Scribner's Sons, New York. 365 pp.

Controlled burns are recommended for opening marshlands so they may be grazed by geese, and for stimulating growth of smartweeds which otherwise cannot compete with ranker vegetation. "Patch" burning is proposed as the best burning strategy for wetlands, many of which can be burned in dry years. [K–L–S]

92. Gresham, C. A. 1985. Clearcutting not enough for early establishment of desirable species in Santee River swamp. South. J. Appl. For. 9:52–54.

Shearing or prescribed burning is recommended to dispose of residual stems and logging slash and to prepare a seedbed in southern hardwood bottomlands. Without postharvest treatment, regeneration species composition and spatial distribution was not considered acceptable. [From author's abstract]

93. Griffith, R. W. 1941. Waterfowl management on Atlantic coast refuges. Trans. N. Am. Wildl. Conf. 5:373–377.

The five principal management practices for Atlantic coast refuges are water manipulation, planting, vegetation control, controlled burning, and the production of supplementary food crops. A combination of fresh and brackish feeding grounds and provisions for water level manipulation within managed units are prerequisites to proper management. Controlled burning rejuvenates needle rush and permits utilization of American bulrush rootstocks when marshhay cordgrass-bulrush stands are burned. Removal of dead cordgrass leads to increased use by not only geese, but

also greater and lesser yellowlegs and common snipe. [K–L–S]

94. Gunderson, L. H. 1984. Regeneration of cypress in logged and burned stands at Corkscrew Swamp Sanctuary, Florida. Pages 349–357 *in* K. C. Ewel and H. T. Odum, eds. Cypress swamps. University Presses of Florida, Gainesville.

Cypress stands that were logged (1954), burned (1962), and logged and burned (1954, 1962) were evaluated in 1975–1979. Cypress was present and regenerating in a burned area and a logged area, but not in a logged and burned site. Coastal plain willow was dominant and regenerating on burned sites; various hardwoods were present and regenerating on the logged sites. The lack of seed sources, immobility of cypress seed, low seed viability, failure to achieve moisture requirements, as well as the existing vegetation, seemed to retard cypress regeneration. Successional schemes incorporating logging and burning are presented for south Florida cypress swamps. [From author's abstract]

95. Hackney, C. T., and A. A. de la Cruz. 1978. The effects of fire on the productivity and species composition of two St. Louis Bay, Mississippi tidal marshes dominated by *Juncus roemerianus* and *Spartina cynosuroides*, respectively. J. Miss. Acad. Sci. 23 (suppl.):109.

Recovery following burn was rapid in the big cordgrass stand with a maximum standing crop of 1,858 g/m^2 by the end of the first growing season. The maximum standing crop decreased in the second season to 1,304 g/m^2 which was similar to controls; dead material in the burn increased to near control levels at the end of the first season. Recovery in the needle rush community was slower. Maximum standing crop at the end of the first season was 864 g/m^2 in the burn versus 1,280 g/m^2 in the controls. The standing crop remained lower in the second season, and the accumulation of dead material was still 331 g/m^2 lower after two growing seasons. Seven additional marsh plant species were found in both communities. Their abundance did not change following fire. [From authors' abstract]

96. Hackney, C. T., and A. A. de la Cruz. 1981. Effects of fire on brackish marsh communities: management implications. Wetlands 1:75:86.

Winter cover burns on needle rush and cordgrass tidal marsh communities along the Mississippi coast increased the net primary production of the aerial portions of plants in the two marsh types by 56% and 49%, respectively. However, burning altered plant species composition and destroyed biomass destined for export to nearby aquatic ecosystems. Caution is urged in using fire as a management tool because its effects on all components of a marsh ecosystem are not known. A management scheme wherein portions of a marsh are burned on a rotational basis, allowing various successional stages to be maintained, is suggested. This will provide diverse habitats suitable for fur-bearing mammals and migratory birds as well as for other life forms not of direct economic importance. [K–L–S]

97. Hackney, C. T., and O. P. Hackney. 1976. Nesting of the mottled duck in Mississippi. Miss. Kite 6:5.

A mottled duck nest with six eggs was located in a stand of 2 m-high living needle rush that had been blown over by wind. The nest was well-concealed and approximately 100 m from the nearest bodies of water. This specific nesting habitat is irregularly available on the Gulf coast because muskrat trappers haphazardly manage needle rush marshes by burning them every 1 to 2 years. After burning, 2 to 5 years are required before the marsh returns to high needle rush. The high stage of the marsh is very dense, possibly providing efficient protection from predators. Nests in the early successional stages of needle rush would be vulnerable to the raccoons common to coastal marsh. [K–L–S]

98. Hamilton, D. B. 1978. Effects of fire, drought, and logging on plant succession in Okefenokee Swamp. Bull. Ecol. Soc. Am. 59:101. (Abstract only)

Following a severe drought in 1954, fires burned 80% (128,690 ha) of the Swamp. Interpretation of aerial photographs showed that vegetation communities were relatively unchanged and had recovered quickly. Successional retrogression was apparent in only

a few areas. Drought permits germination of pondcypress, but logging significantly alters the character of the vegetation. [From author's abstract]

99. Hamilton, D. B. 1982. Plant succession and the influence of disturbance in the Okefenokee Swamp. Ph.D. Dissertation. University of Georgia, Athens. 277 pp.

[See Hamilton 1984]

100. Hamilton, D. B. 1984. Plant succession and the influence of disturbance in Okefenokee Swamp. Pages 86–111 *in* A. D. Cohen, D. J. Casagrande, M. J. Andrejko, and G. R. Best, eds. The Okefenokee Swamp: its natural history, geology, and geochemistry. Wetland Surveys, Los Alamos, NM.

Plant succession and the influence of logging and periodic fires were studied using field surveys and aerial photography. The general pattern of succession is from prairie to cypress swamp with eventual transition to either climax mixed swamp tupelo or bay swamp in the absence of disturbance. Periodic fires tend to maintain existing vegetation and generally prevent successional transition. Although even severe peat burns are restored to approximate prefire floristic composition through secondary succession, it is unlikely that areas logged for cypress can return to prelogging floristic composition. Diagrams of plant successional pathways and a vegetation map of the Okefenokee Swamp are provided. [From author's abstract]

101. Hanson, H. C. 1939. Fire in land use and management. Am. Midl. Nat. 21:415–434.

In a review of the general effects of fire, it is emphasized that peatlands and other wetlands should not be burned, drained, or otherwise interfered with in any way that hinders their ability to store water, mitigate floods, and maintain the water level in surrounding lands. [K–L–S]

102. Hebb, E. A., and A. F. Clewell. 1976. A remnant stand of old-growth slash pine in the Florida panhandle. Bull. Torrey Bot. Club 103:1–9.

Slash pine in the Gulf of Mexico coastal plain is considered a climax maintained by fire which kills back shade tolerant hardwood trees and shrubs and restricts slash pine to wetter sites. A small remnant stand of slash pine was probably established when a heavy seed crop preceded by a fire was followed by several dry years that did not flood seedlings. It now has no reproduction and the older trees show signs of heart rot. Unless diverted by fire (a presently precluded management practice), development of a bay swamp is predicted, with new dominants, largely swamp tupelo and sweetbay, derived from the current understory. [K–L–S]

103. Heinselman, M. L. 1981. Fire intensity and frequency as factors in the distribution and structure of northern ecosystems. Pages 7–57 *in* H. A. Mooney, T. M. Bonnicksen, N. L. Christensen, J. E. Lotan, and W. A. Reiners, tech. coords. Proceedings of the conference: fire regimes and ecosystem properties. 11-15 December. 1978, Honolulu, HI. U.S. For. Serv. Gen. Tech. Rep. WO–26.

Presettlement forests of much of North America were strongly fire-dependent. Historical changes in fire regimes, the role of fire in regulating vegetation structure, the reciprocal influence of community structure on fire frequency, and variations in ecosystem development (succession) under presettlement, contemporary, and managed fire regimes for five ecosystems are presented. The large peatlands and smaller bogs and swamps of the northern Lake States, Canada, and Maine support boreal vegetation, but their fire regimes are different from those of areas with mineral soil. Forested peatlands with a moss ground layer will not readily carry spring ground fires because they are too wet and there is no highly flammable layer. In contrast, sedge and grass fens, even those with partial tree cover, burn best in spring before succulent vegetation develops. Thus, most fires in forested peatlands occur in July, August, or September of severe drought years, and most fires in sedge-grass fens occur in April, May, or early June. The presettlement fire regime for large forested spruce bogs in Minnesota was

one of long return interval crown fires with a fire cycle of perhaps 100–150 years. The vast grass-sedge fens of north-central and northwestern Minnesota burned at more frequent intervals of periodic surface fires with fire cycles of 5–30 years. Removing fire from northern ecosystems would be among the greatest upsets in the environment that man could impose. [K–L–S]

104. Hess, T. J., Jr. 1975. An evaluation of methods for managing stands of *Scirpus olneyi*. M.S. Thesis. Louisiana State University, Baton Rouge. 98 pp.

The response of Olney bulrush and marshhay cordgrass to irrigation with water of differing salinities during drought and to burning was studied at Rockefeller Refuge and in a greenhouse. Twenty ppm salinity decreased culm density. Water levels above the soil surface increased bulrush culm height and density; water levels below the surface had the opposite effect; marshhay cordgrass was not affected by different water levels. Burning in fall, winter, and spring, and during increasing and decreasing moon phases had no effect on culm density of either species. [From author's abstract]

105. Higgins, K. F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. U.S. Fish Wildl. Serv., Resour. Publ. 161. 39 pp.

This review provides resource managers with background information to justify the study or use of fire in management and provides reference to historical fire accounts in the Northern Great Plains. The most frequently recorded fires were scattered short-duration events of small extent. Fires were recorded to have occurred in wetlands, but wetlands as well as sandy soil sites usually provided refuge from fire. Historical accounts support the conclusion that Native Americans of the Northern Great Plains did not subscribe to annual wholesale or promiscuous burning practices, but that they did use fire as a tool to aid hunting and gathering activities. Man-caused fires did not match the seasonal pattern of lightning fires, but more likely correlated with bison herd movements. [From author's abstract]

106. Hochbaum, G. S., L. T. Kummen, and F. D. Caswell. 1985. Effects of agricultural burning on occupancy rates of small wetlands by breeding ducks. Can. Wildl. Serv. Prog. Notes 155. 3 pp.

A study of 1,307 ponds in southern Manitoba and southeastern Saskatchewan revealed no relationship between burning of the pond margin and subsequent pond use by breeding pairs. Ponds with burned and unburned margins are equally important components of duck home ranges prior to breakup of pairs, but the burning of pond margins probably affects nest success (because of loss of cover) and brood survival (because birds are forced to nest further from water). [K–L–S]

107. Hodge, A. E. 1985. Successional relationships of major plant communities in Carolina bays. Estuaries 8(2B):95A. (Abstract only)

Recent studies of Carolina bays in South Carolina suggest that several factors, including hydrology, fire, edaphic conditions, and physical disturbances of the substrate, influence vegetation development and successional patterns. Successional relationships are related to these factors. [From author's abstract]

108. Hoffpauir, C. M. 1961*a*. Methods of measuring and determining the effects of marsh fires. M.S. Thesis. Louisiana State University, Baton Rouge. 54 pp.

[See Hoffpauir 1961*b* and 1968.]

109. Hoffpauir, C. M. 1961*b*. Methods of measuring and determining the effects of marsh fires. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 15:142–161.

This study devised methods of measuring and evaluating marsh fires and factors affecting them, and assessed their effects in the Rockefeller Refuge, LA. Postburn water samples showed increases in pH, sodium and potassium content, chlorinity, and total alkalinity. Most of these increases were greatly depleted after 49 days by tidal action, rainfall, and regrowth. Soil temperatures on burned areas were consistently higher than on adjacent nonburned areas. However, soil temperatures did not increase during burning when the water

level was at marsh level or higher. To reduce undesirable plant species (e.g., marshhay cordgrass) and favor preferable species (e.g., Olney bulrush) the water level must be below the soil level during burning to ensure root damage; otherwise, the burning causes immediate nutrient addition to the soil, promoting the growth of the undesirable species. Geese feeding on burned areas sometimes eliminate plant rootstocks, preventing stand regrowth. [From author's abstract]

110. Hoffpauir, C. M. 1968. Burning for marsh management. Pages 134–139 *in* J. D. Newson, ed. Proceedings of the Marsh and Estuary Management Symposium. Louisiana State University, Baton Rouge.

Three types of marsh burns are described: the cover or wet burn, made in a marsh where water levels are at or above the root horizons; the root burn, which causes damage to plant root systems by fire and heat; and the deep peat burn, which is the result of fire occurring during a very dry spell in a marsh with a peat or mucky peat soil overlaying a clay pan. Climatic conditions and tide action or heavy rain can modify vegetation regrowth or reverse vegetation dominance. Management implications are given for snow and Canada geese and northern pintail ducks. [K–L–S]

111. Hofstetter, R. H. 1974*a* The ecological role of fire in southern Florida. Fla. Nat. 47:2–9.

The role of wet season fires in maintaining plant communities in south Florida is outlined. Draining of wetlands has increased the incidence of dry season fires which earlier only rarely occurred. Protection and maintenance of some desirable communities can only be accomplished with prescribed burning. Otherwise, fire subclimax communities advance to the next seral stage. Prescribed burning is ecologically sound, economical, and necessary for maintenance of natural communities. [K–L–S]

112. Hofstetter, R. H. 1974b. The effect of fire on the pineland and sawgrass communities of southern Florida. Pages 201–212 *in* P. J. Gleason, ed. Environments of south Florida: present and past. Miami Geol. Soc. Mem. 2.

Fire is a natural force affecting all terrestrial and wetland communities in southern Florida. Hardwood succession is deterred in marshes and pinelands by fire. Natural fires occur mostly in the wet season, but man has made destructive dry-season fires more common. Vegetation changes following prescribed burning in pineland and sawgrass and the effects of fire upon selected animals are discussed. Fire and other factors will have to be managed to maintain the natural communities of southern Florida. [From author's abstract]

113. Hopkins, J. M. 1947. Forty–five years with the Okefenokee Swamp 1900–1945. Ga. Soc. Nat. Bull. 4. 69 pp + plates.

A deliberately set fire in 1932 killed 40 to 50 million board feet of swamp tupelo, several million feet of large slash pine, and a large percentage of the sweetbay trees; damage to pondcypress was negligible. The only wildlife remains found were snakes, which for many years after were in lower numbers in the swamp. Extended drought permitted this large-scale damage. Fire protection was conceded to be impossible in dry years and unnecessary in wet years, but the drier uplands could be protected by the timber companies. [K–L–S]

114. Hovind, R. B. 1949. Controlled burning of public hunting grounds. Wis. Conserv. Bull. 14:13–15.

Controlled burns at Horicon Marsh, WI, remove plant debris from pond basins, create potholes, stimulate new growth, develop feeding and resting areas for migrant geese, control alder and willow growth, break up monotypic vegetation stands, and reduce the chances of wildfires. [K–L–S]

115. Hughes, J. H., and E. L. Young, Jr. 1982. Autumn foods of dabbling ducks in southeastern Alaska. J. Wildl. Manage. 46:259–263.

Dabbling ducks on the Stikine Wildlife Management Unit of the Tongass National Forest were found to depend heavily upon sedges, the dominant species. Thus, although burning might remove dead material and

expose new growth, it would probably not increase carrying capacity. Although fire is not viewed as detrimental to dabbling ducks in this marsh, its potentially deleterious effects to other wildlife and minimal advantages preclude its use. [K–L–S]

116. Hughes, R. H. 1957. Response of cane to burning in the North Carolina Coastal Plain. N.C. Agric. Exp. Stn. Bull. 402. 24 pp.

Giant cane is renovated by carefully controlled fires. Vigor is restored, productivity replenished, fire hazard reduced, and accessibility of the cane to livestock is increased for 1 to 3 years. Cane stands thinned and declined in productivity after about a decade of fire protection. When undisturbed 14 years, cane stems declined 65% during the final 7 years. Grazing management alone cannot restore high productivity to cane. In contrast, foliage production was materially improved by burning except for the first season after fire. The optimum management prescription where grazing is an objective is winter burning at intervals of about 10 years. Maximum forage production may be expected 2 to 4 years after burning; good production will be maintained an additional 6 to 8 years. Since burning increases susceptibility to grazing damage, grazing should be carefully regulated during the summer months, especially immediately after burning. [From author's abstract]

117. Hughes, R. H. 1966. Fire ecology of canebrakes. Proc. Annu. Tall Timbers Fire Ecol. Conf. 5:149–158.

Giant cane, a native bamboo, only exists in a portion of its original range, but forms extensive canebrakes in swamplands and low-lying coastal areas in the southeastern United States. This species thrives in a fire-maintained community; without periodic fire, stands stagnate. Fire, accompanied by carefully regulated grazing, can maintain stands of this most productive native grazing type. Regeneration of pond pine, the common overstory component of the cane type, is likewise most probably the product of recurrent fire. [K–L–S]

118. Ivester, M. S., and C. J. Harp. 1978. Effect of marshland fires on meiofaunal community structure. Am. Zool. 18:661. (Abstract only)

The immediate impact of fire in an Alabama smooth cordgrass/needle rush marsh was to reduce meiofaunal abundance by approximately 60%. Three to four months after the burn, meiofaunal densities did not differ between burned marshes and controls. Variation postburn was primarily in the abundance of the species and in some cases, a shift in dominance of species. [From authors' abstract]

119. Izlar, R. L. 1984. Some comments on fire and climate in the Okefenokee Swamp–Marsh complex. Pages 70–85 *in* A. D. Cohen, D. J. Casagrande, M. J. Andrejko, and G. R. Best, eds. The Okefenokee Swamp: its natural history, geology, and geochemistry. Wetlands Surveys, Los Alamos, NM.

Fire plays a dominant role in the extremely complex and fragile ecology of the Okefenokee. Prairie maintenance and successional retardation are dependent upon fire. Although public opinion opposes fire, historical evidence suggests a naturally occurring cycle of drought and attendant fires every 25–30 years. The exclusion of fire would clearly signal the end of the swamp as we know it. The interrelationships of weather, lightning, and fire are explored in a historical review. [From author's abstract]

120. Johnson, R. E. 1976. An evaluation of 2,4-D amine and fire to control pest plants occurring in a beaver pond managed for waterfowl in Macon County, Alabama. M.S. Thesis. Auburn University, Auburn, AL. 43 pp.

Food habits of wintering ducks were studied on an Alabama beaver pond in 1972–74. Three of the most abundant plants were important duck foods: redroot flatsedge, swamp smartweed and slimfruit marshpurslane. The most abundant plant, hemp sesbania, was not used. Treatments with 2,4-D amine applied at 1.0 lb/acre and fire were compared with controls on 60 0.01-acre plots established in 1974. Posttreatment seed yields for redroot flatsedge were significantly higher in herbicide treated plots; yields for hemp sesbania and slimfruit marshpurslane were significantly lower. Percent cover of redrooted flatsedge and swamp

smartweed increased significantly in herbicide plots but decreased elsewhere; hemp sesbania showed the reverse response. There was no significant difference between fire–treated and control plots. The herbicide 2,4-D amine can be used to increase duck food in beaver pond habitat by controlling unwanted plants. Fire, on the other hand, appears unusable in beaver ponds until improved techniques are developed. [From author's abstract].

121. Kaiser, P. H., S. S. Berlinger, and L. H. Fredrickson. 1979. Response of blue-winged teal to range management on Waterfowl Production Areas in southeastern South Dakota. J. Range Manage. 32:295–298.

Blue-winged teal were the predominant upland-nesting waterfowl in southeastern South Dakota Waterfowl Production Areas. Excellent range condition (high proportion of climax vegetation and matted residual material) contributed to high nest density and success in native plant communities. Residual vegetation forming a matted mulch was likewise a determinant of nest density and success in tame plant communities, with smooth brome demonstrating greatest nest density. Management of native plant communities to obtain optimum conditions for waterfowl requires proper use of burning, grazing, resting, and haying. Although best manipulations of tame grass communities are unknown, substantial resting to permit mulch development was an appropriate technique on the areas studied. [K–L–S]

122. Kantrud, H. A. 1986. Effects of vegetation manipulation on breeding waterfowl in prairie wetlands—a literature review. U.S. Fish Wildl. Serv., Fish Wildl. Tech. Rep. 3. 15 pp.

Literature on the effects of fire and grazing on prairie wetlands used by breeding waterfowl is reviewed. Nearly all studies to date indicate that reductions in height and density of tall, emergent hydrophytes by fire and grazing (unless very intensive) benefit breeding waterfowl. Pair densities increase in manipulated habitats, probably from increased interspersion of cover and open water and increased invertebrate food resources. Data are not yet available to provide specific fire prescriptions for prairie wetlands. The need for research to evaluate alternative management schemes is emphasized. [From author's abstract]

123. Kautz, E. W. 1987. Prescribed fire opportunities in the Northeast. Pages 98–100 *in* Society of American Foresters. Forests, the world, and the profession. Proceedings of the 1986 Society of American Foresters National Convention, 5-8 October 1986, Birmingham, AL. Soc. Am. For. Publ. 87.02

Historical use of prescribed fire in the Northeast has depended heavily upon the philosophy of local organizations or administrators in charge. Most response to fire has been fire control. Opportunities for use of fire are great and the reluctance to use fire is decreasing. Three of 23 prescribed fire programs underway in the Northeast at present address wetlands: (1) reduction of marshland fire hazard and wildlife habitat improvement in Minnesota; (2) wetland forage management on the Green Mountain National Forest, Vermont, and in Wisconsin; and (3) fuel reduction for fire prevention on sedge meadows on the Chippewa National Forest, Minnesota. Development of aerial ignition devices and the helitorch, water expansion equipment, efficient computer models, portable automatic weather stations, and use of primacord and gelled gas have increased efficiency in use of fire. Constraints and concerns with regard to the use of prescribed fire are listed. [K–L–S]

124. Kelsall, J. P., E. S. Telfer, and T. D. Wright. 1977. The effects of fire on the ecology of the boreal forest, with particular reference to the Canadian North: a review and selected bibliography. Can. Wildl. Serv. Occas. Pap. 32. 58 pp.

The effects of large fires on hydrology are summarized as increased snowmelt rate, rapidity of runoff, flooding, and erosion. These effects, in turn, cause heavy sedimentation and siltation of streams, but such effects seem limited in northern boreal forests unless fire-fighting activities have damaged the land. The literature indicates no adverse effects of fire on fish or aquatic invertebrates. Ruffed grouse, sharp-tailed grouse, spruce grouse, and ptarmigans obtain new habitat from fire. Habitat changes following fire benefit some large mammals but neither harm or benefit

most small mammals. Beaver and muskrat benefit from fire. Red squirrels, martens, fishers, and other species dependent upon dense coniferous stands are often excluded from areas for many years following heavy burns. Caribou may be excluded from some areas by fire, but fire is not seen as a major factor regulating their populations. Moose and deer benefit from fires that maintain younger growth; mountain goats and bighorn sheep are largely unaffected by fire in their habitat. Larger carnivores probably benefit from the mosaic of habitats resulting from fire. One hundred ninety-nine references are cited. [K–L–S]

125. Kirk, P. W., Jr., editor. 1979. The Great Dismal Swamp. Proceeding of a symposium sponsored by Old Dominion University and United Virginia Bank—Seaboard National 14 March 1974. University Press of Virginia, Charlottesville. 427 pp.

This second symposium on the Great Dismal Swamp (the first was in 1911) was held in response to the formation of Dismal Swamp National Wildlife Refuge. Five contributed papes, two bibliogrphic essays, and contributed papers by thirteen authors discuss the ecology of the Swamp, which is one of the largest remaining swamp forests on the southeastern coastal plain. Papers by Levy and Walker (1979) and Whitehead and Oaks (1979) that discuss the effects of fire on the wetlands of Dismal Swamp are included in this bibliography. [K–L–S]

126. Kirkpatrick, R. C. 1941. Effect of fires on wildlife. Wis. Conserv. Bull. 6:28–30.

The cost to the Wisconsin State government of fires set by careless humans is discussed with specific examples of the effects of spring burning. Inability of spring burns to control weeds and wildlife considered pests is emphasized, despite wide use of the practice. Marsh burns destroy cover, kill groundnesting birds, and reduce nest success. Erosion and siltation after fire destroy water quality and reduce the value of lakes and streams; aesthetic losses are also considerable. [K–L–S]

127. Klukas, R. W. 1973. Control burn activities in Everglades National Park. Proc. Annu. Tall Timbers Fire Ecol. Conf. 12:379–425.

A review is provided of the expansion of control burn activities, previously confined to pinelands habitat of the Park, to include all fire-dependent habitats within the Park, covering about 1,777 km^2. The plant communities of the Park are described, as are their responses to controlled burning. [K–L–S]

128. Kologiski, R. L. 1977*a*. Phytosociology of the Green Swamp, North Carolina. Ph.D. Dissertation. North Carolina State University, Raleigh. 169 pp.

[See Kologiski 1977*b*]

129. Kologiski, R. L. 1977*b*. The phytosociology of the Green Swamp, North Carolina. N.C. Agric. Exp. Stn. Tech. Bull. 250. 101 pp.

The Green Swamp is characterized by organic soils, long hydroperiods, frequent fires, and semi-evergreen shrubby vegetation. Natural fires were always a factor in development of Green Swamp vegetation, but man has been a major cause of fire in the past several hundred years. A general successional pattern, from frequent fire to absence of fire, can be discerned in 14 recognized community types which may be summarized as follows: Sedge Bogs develop after deep peat burns destroy the roots of previous vegetation. This type succeeds to Pine-Ericalean Pocosin which is established and maintained by fire. The Evergreen Bay Forest develops in pocosins that have not had recent burns. This community is relatively stable, but may succeed to Deciduous Bay Forest species, a rare community only present in areas without disturbance. The Atlantic White-cedar Forest is highly susceptible to fire so only develops in areas void of recent fires. The Conifer Hardwood Pocosin exists in areas of frequent fire and disturbance and appears to be an early successional stage of the Deciduous Bay Forest. Pine Savannas are the most floristically diverse communities and are maintained by frequent fire. Intelligent fire and drainage practices are the keys to preservation and perpetuation of the dominant vegetation type in Green Swamp—the pocosin. [From author's abstract]

130. Komarek, E. V. 1971. Effects of fire on wildlife and range habitats. Pages 46–52 *in* U.S. Forest Service, ed. Prescribed burning symposium proceedings. Southeast. For. Exp. Stn., Asheville, N.C.

There is abundant evidence, both experimental and observational, that fire is essential in the management of wildlife and plants in southeastern pine forests, grasslands, and adjacent wetlands. Using the example of the northern bobwhite, the value of fire in maintaining the complex of habitat types needed by numerous species in the Southeast is illustrated. [K–L–S]

131. Komarek, E. V. 1985. Wildlife and fire research: past, present, and future. Pages 1–7 *in* J. E. Lotan and J. K. Brown, compilers. Fire's effects on wildlife habitat—symposium proceedings. Missoula, Montana, 21 March 1984. U.S. For. Serv. Gen. Tech. Rep. INT-186.

Past use (or lack thereof) of fire in southern and western ecosystems is reviewed. Unpublished information on survival of salt marsh snails and periwinkles following burns suggests greater snail densities on burned than unburned coastal marshes. The general paucity of information on invertebrate response to fire is illustrated. It is suggested that any study of fire–invertebrate relationships would fill major gaps in our knowledge of fire effects. [K–L–S]

132. Korstian, C. F. 1924. Natural regeneration of southern white-cedar. Ecology 5:188–191.

Atlantic white-cedar is susceptible to fire at all ages. Logging slash will burn to the water's edge when the swamp is wet. During dry conditions, the upper portion of the peat will also burn. Dense regrowth appears after a single burn. A second burn, regardless of season, will eliminate the type because the new growth either does not have enough time to set seed before being consumed by fire, or the seed in the upper layers of the forest floor is destroyed, or both. Thus, although opportune fires may remove slash and release the white-cedar, others devastate the type and cause replacement by hardwoods, pine, or both. [K–L–S]

133. Korstian, C. F., and W. D. Brush. 1931. Southern white-cedar. U.S. Dep. Agric. Tech. Bull. 251. 75 pp. + illus.

In a review of the life history, management, and economic importance of Atlantic white-cedar, the susceptibility of the species to fire is emphasized. Fires in slash a few years after logging are most harmful, since young growth is destroyed. Fires which burn the upper layers of peat in dry season destroy the white-cedar seed bank, and a second fire at any time can remove cedar completely from the forest. [K–L–S]

134. Kozlowski, T. T., and C. E. Ahlgren, editors. 1974. Fire and ecosystems. Academic Press, New York. 542 pp.

This comprehensive text covers in 13 separate chapters the harmful and beneficial effects of fire upon soils, soil organisms, birds and mammals, and plants. The effects of fire upon flora are discussed in 9 separate chapters that cover grasslands, temperate forests, chapparal, and deserts and desert grasslands of North America as well as the Mediterranean region and forest and savanna ecosystems of Sub-Saharan Africa. A final chapter discusses the use of fire in land management. All chapters provide a comprehensive synthesis and substantial literature citations valuable to those interested in the temperate systems of the United States and other ecosystems addressed. The chapter by Bendell (1974) on effects of fire on fauna is included in this bibliography. [K–L–S]

135. Kramp, B. A., D. R. Patton, and W. W. Brady. 1983. The effects of fire on wildlife habitat and species. RUN WILD Wildlife/Habitat Relationships. Tech. Rep. U.S. For. Serv., Southwest. Reg., Albuquerque, NM. 29 pp.

This report organizes literature on the effects of fire on wildlife for resource managers, particularly in the Southwest. Fire effects on wildlife habitat, wildlife fire response classifications, and detailed fire effects for classes and species of vertebrates are given through discussion of 173 references that relate fire effects for much of North America. Numerous birds, mammals, reptiles, amphibians, and fish found in or near wetlands

are specifically discussed. [From authors' abstract]

136. Landers, J. L. 1987. Prescribed burning for managing wildlife in southeastern pine forests. Pages 151–159 *in* Society of American Foresters. Forests, the world, and the profession. Proc. 1986 Soc. Am. For. Nat. Conv., 5-8 October 1986, Birmingham, AL. Soc. Am. For. Publ. 87.02 [Also published in 1987 with the same title as: Pages 19–27 *in* J.G. Dickson and O.E. Maughan, eds. Managing southern forests for fish and wildlife: a proceedings. U.S. For. Serv. Gen. Tech. Rep. SO-65.]

There is much ecological evidence that recurring fires have been a long-standing evolutionary agent of habitat change to which native wildlife are adapted in the Southeast. Wildlife mortality from fire is generally negligible. Literature on fire effects upon reptiles and amphibians, birds (nongame forest and upland game), and mammals (small, tree squirrels, rabbits, furbearers, black bear, white-tailed deer) are summarized. In general, little is known of fire effects upon truly aquatic herps. Although the American alligator and Pine Barrens tree frog benefit from habitat change caused by fire, more research is needed on other aquatic and semiaquatic wildlife. Fire directly affects the abundance of a species through changes in vegetation. Prescribed burning is a very underutilized tool for management of southeastern pine forests, but a critical evaluation is needed before its usefulnes can be fully realized in even a single-species plan, e.g., if the habitat is decadent, the fire might provide quick benefits; if not, fire might set back the target species in the short term. Research needs are listed. [K–L–S]

137. Landers, J. L., A. S. Johnson, P. H. Morgan, and W. P. Baldwin. 1976. Duck foods in managed tidal impoundments in South Carolina. J. Wildl. Manage. 40:721–728.

The relation between management of tidal impoundments in a South Carolina estuary, vegetative composition in these impoundments, and the diet of wintering ducks using them is reported. Several freshwater peat marshes examined were drained as much as possible during the growing season, then burned and flooded in the fall. This encouraged the important duck foods redroot flatsedge and panicum. [K–L–S]

138. Lawrence, W. H. 1954. Michigan beaver populations as influenced by fire and logging. Ph.D. Dissertation. University of Michigan, Ann Arbor. 232 pp.

Natural catastrophes such as fire, windthrow, and more recently, lumbering, develop favorable environmental conditions for beaver. Beaver are dependent upon a temporary forest type, aspen. Forest fire suppression, silvicultural practices, and the tree felling of beavers augment rapid replacement of the aspen type bordering streams. The current peak in beaver numbers can only continue as long as aspen remains available within approximately 100 m from the water's edge. Understanding the ecology of the beaver and its role in a response to environmental succession provides a new basis for beaver management. Management should attempt to integrate beaver management with naturally occurring environmental change in the aspen-conifer ecosystem. Management on a streamwise basis is advised. [From author's abstract]

139. Lay, D. W. 1945. Muskrat investigations in Texas. J. Wildl. Manage. 9:56–76.

Burning is part of a scheme to manage marshes for muskrats on the southeastern Texas coast. Olney bulrush, an important muskrat food, is encouraged by burning in late summer. At this time, marshhay cordgrass, the climax species, is set back and the bulrush can outcompete it. Spring burns work the reverse. [K–L–S]

140. Lay, D. W., and T. O'Neil. 1942. Muskrats on the Texas coast. J. Wildl. Manage. 6:301–311.

In a fresh to slightly brackish marsh, burning increased the desirable cattail and saltmarsh bulrush, and decreased smooth cordgrass and sawgrass. Late winter burning on an annual basis appears to be the best management scheme. In a brackish marsh, fall burning to increase green cattle forage in late fall and winter has reduced cover for muskrats. Burns in dry years resulted in too much removal; lakes resulted. Cessation of burning led to loss of desirable vegetation after 2 years.

Impoundments appear to be the preferable approach to management of these marshes. In a brackish to saline marsh, a severe late summer burn (set by trappers to prevent late burning by cattlemen) followed by drought and salt tides ruined the area for muskrats. Late recovery of the vegetation attracted geese which severely damaged the marsh and perhaps led to semipermanent loss of land to open water. Burning of alternate strips is a more desirable management plan for this marsh. In all three types of marsh, burning is an important tool in muskrat management. [K–L–S]

141. Leon, B. F. 1979. Disturbance tolerance and competition in brackish marsh plants. Ph.D. Dissertation. Princeton University, Princeton, NJ. 109 pp.

Variations in the mixture of plant species in a brackish Maryland Eastern Shore marsh are a result of differential disturbance and competition among species. Species may be ordered with regard to their tolerance of fire and muskrat trenches. Competition and disturbance tolerance, not limitations of physical factors, determine the plant distribution of this marsh. [From author's abstract]

142. Levy, G. F., and S. W. Walker. 1979. Forest dynamics in the Dismal Swamp of Virginia. Pages 101–126 *in* P. W. Kirk, Jr., ed. The Great Dismal Swamp. Proceeding of a symposium sponsored by Old Dominion University and United Virginia Bank—Seaboard National 14 March 1974. University Press of Virginia, Charlottesville.

The Dismal Swamp has been greatly disturbed by numerous fires and about 200 years of logging. Most plant communities occurring in the Dismal Swamp today consist of second or third growth forest and dense brushlands in a variety of seral stages. Logging and burning particularly have simplified or isolated communities and altered seed availability. Present vegetation can be divided into rather distinct communities caused, in part, by disturbance. [K–L–S]

143. Lewis, F. J., and E. S. Dowding. 1926. The vegetation and retrogressive changes of peat areas in central Alberta. J. Ecol. 14:317–341.

The vegetation, history, and retrogressive changes of muskegs in the poplar parkland district of Edmonton are described. The authors conclude that current retrogression results from desiccation caused by climatic change and general clearing and draining. Fire, although locally important, is not responsible for general shrinkage in growth and vegetation change in these peatlands. [K–L–S]

144. Lewis, F. J., E. S. Dowding, and E. H. Moss. 1928. The vegetation of Alberta II. The swamp, moor and bog forest vegetation of central Alberta. J. Ecol. 16:19–70.

The succession of associations within vegetation formations is related to burning, mowing, grazing, draining, and biotic factors such as browsing by wildlife and flooding by beaver. Burning is significant in that it reduces topographic relief through removal of peat, thus setting succession back to earlier seral stages. [K–L–S]

145. Linde, A. F. 1969. Techniques for wetland management. Wis. Dep. Nat. Resour. Res. Rep. 45. 156 pp.

Controlled burning is one of various wetland management techniques discussed in this publication. This practice is highly effective in: (1) removing annual "rough" or dead herbaceous cover, thus preventing build-up of debris on the marsh floor; (2) reducing the level of the marsh floor by burning into organic soils; (3) reducing or eliminating woody vegetation in impoundments; (4) destroying sphagnum moss and bringing about succession to sedge and grasses, thus creating nesting areas for waterfowl; (5) cleaning impoundment basins prior to flooding; and (6) producing open areas that will provide better spring grazing for waterfowl. These points are elaborated upon, with special reference to Wisconsin. Techniques for prescribed burning are discussed. [K–L–S]

146. Linde, A. F. 1985. Vegetation in water impoundments: alternatives and supplements to water level control. Pages 51–60 *in* M.D. Knighton, compiler. Proceedings, water impoundments for wildlife: a habitat management workshop. U.S. For. Serv. Gen Tech. Rep. NC-100.

Control burning, crushing and mowing, using herbicides, wetland farming, tillage farming, mudflat farming, reflooding, and modification of semidry wetlands are discussed as means to manage impoundment vegetation. Burning is one of the cheapest tools available for large scale habitat changes of either short- or long-term. Poorly planned, poorly scheduled, and poorly implemented burns, however, can be quite destructive. Advance planning, experienced crews, and proper clearance from local authorities are important parts of the burn operation. The major uses of fire include winter burning, which removes annual "rough" in marshes, provides openings that green-up early for waterfowl in the spring, and sets back plant succession. Similarly, slow-moving fires in dry conditions can reduce marsh floor levels, creating open water in the marsh when water is returned. Peat burns, however, are difficult to control, and should only be initiated if there is assurance they can be extinguished. Another use is summer or hot weather burning to control woody vegetation and to open up peat moss and Cassandra leatherleaf bogs for later growth of sedges and grasses. During impoundment construction, excess ground litter and excess woody cover in the basin may be burned prior to flooding. Finally, irregular, patchy burns on semidry sedge/grass areas during winter can be used to increase edge and access by waterfowl during the nesting season. Forage produced after a fire is usually more palatable and nutritious. Flowers, fruit, and seeds are produced in greater number and are more available. For the benefit of waterfowl and other birds, avoid burning April-June; late summer or fall burns are best. Burn in strips to reduce conflict with hunting activities. Winter and early spring burns do not conflict with other interests, but it may be difficult to accomplish burns if there is much snow cover. [K–L–S]

147. Linduska, J. 1960. Fire for bigger game crops. Sports Afield 143(1):30–31, 88–90.

This popular article reports on the use of fire as a marsh management tool in different areas of the United States. In Lake Erie duck marshes, "cold" burning in spring enhances coast barnyardgrass, rice cutgrass, and softstem bulrush. In the Southeast, fire is used for marsh brush control. Burning along the Gulf coast simplifies muskrat trapping, reduces the chances of wildfires, and removes debris from sawgrass marshes, thereby exposing seed to waterfowl and encouraging new green shoots of marshhay cordgrass and seashore saltgrass. [K–L–S]

148. Little, S., Jr. 1950. Ecology and silviculture of white cedar and associated hardwoods in southern New Jersey. Yale Univ. School For. Bull. 56. 103 pp. + 9 illus.

Atlantic white-cedar has a patchy distribution in a narrow coastal belt 80 to 160 km (50 to 100 miles) wide from southern Maine to central Florida and westward to southeastern Mississippi. It occurs on poorly drained peat or sandy soils in which the organic matter may range in depth from a few centimeters to over 9 m. The soils are acidic, the pH ranging from 2.0 to 5.5. White-cedar is commercially valuable and most stands have been heavily cut. The associated hardwoods have little or no value. Seed production is great for white-cedar, but seedlings require substantial light, sufficient (but not too much) water, and lack of thick litter and slash. White-cedar grows better than most potential competitors on wet sites and over high water tables, but previous fires and cuttings have much to do with present distributions. Wet swamps usually serve as firebreaks, but hot fires can burn into white-cedar from upland sites. Surface fires in wet years have beneficial effects; in dry years, peat may be consumed down to mineral soil. Variables which determine whether white-cedar will be maintained or invade a site after fire include composition of the original stand, amounts of viable seed, composition of nearby stands, the depth of the burn, and the height of the water table after the burn. In general, the effects of fire on the white-cedar type since 1700 have been detrimental. Appropriate silvicultural techniques for the species are listed. [From author's abstract]

149. Little, S. 1979. Fire and plant succession in the New Jersey Pine Barrens. Pages 297–314 in R. T. Forman, *ed.* Pine Barrens: ecosystem and landscape. Academic Press, New York.

Fire history on swamp sites in the Pine Barrens differs from that in upland sites because wildfires seldom start or spread on wet swamp

sites containing Atlantic white-cedars or swamp hardwoods. When fires do occur, these thin-barked trees are often killed or wounded. Stand composition may change dramatically after fire because white-cedar will not sprout after stems are killed. During severe droughts, fires may remove deep layers of organic soil. The subsequent plant reproduction on a swamp site depends upon the depth of organic soil consumed relative to the normal water table level, the numbers of hardwood trees and shrubs remaining, and available seed sources. Trees cannot reproduce in areas of standing water until sphagnum mosses build a suitable seedbed. If organic soil is not removed, white-cedar stands subsequently may be dominated by swamp hardwoods, if they were present in the previous stand. If not, cedar seedlings may produce another pure stand. Deer browsing can severely limit development of young white-cedars after fire. Shrub and herb layer changes include development of quaking bogs in areas where water is several centimeters deep as a result of burning of organic material. If water is shallower, extensive Cassandra leatherleaf cover may develop. Where fires are deep enough to destroy shrubs, but standing water does not develop, temporary meadows may form. [K–L–S]

150. Lotan, J. E., M. E. Alexander, S. F. Arno, R.E. French, O. G. Langdon, R. M. Loomis, R. A. Norum, R. C. Rothermel, W. C. Schmidt, and J. Van Wagtendonk. 1981. Effects of fire on flora: a state-of-knowledge review. U.S. For. Serv. Gen. Tech. Rep. WO-16. 71 pp.

Discussions are organized around the effects of fire upon the major vegetation types described by A. W. Kuchler [1966. Potential natural vegetation (map). U.S. Geol. Surv. Nat. Atlas, sheets 88 and 89; for additional information see A. W. Kuchler. 1964. Potential natural vegetation of the conterminous United States (map and manual). Amer. Geogr. Soc. Spec. Publ. 36]. Data on understory vegetation are included, as are sections on the general description of the flora, its autoecology and synecology, fire characteristics in the vegetation type, threatened and endangered species present, management implications, and research needs. An introduction to the literature pertinent to all biogeographic regions in the United States, including those without trees (prairies, deserts), is addressed through presentation of data from 341 citations. [K–L–S]

151. Lotspeich, F. B., and E. W. Mueller. 1971. Effects of fire in the taiga on the environment. Pages 45–50 *in* C. W. Slaughter, R. J. Barney, and G. M. Hansen, eds. Fire in the northern environment—a symposium. U.S. For. Serv., Pac. Northwest For. Range Exp. Stn., Portland, OR.

Findings from a study of fire effects on the aquatic environment lead to the conclusion that the fire had fewer deleterious effects than did activities from fighting the fire—improper siting of "cat" lines as an example. Permafrost is a complicating factor that requires careful consideration when making decisions on where and how to contain a fire. Heavy application of phosphate-base retardants may cause early eutrophication of lakes. A decision must be made on intensive versus nominal efforts to control a given fire. Each fire is unique. The total ecosystem, with variations, must be considered in addition to the economic value of the forest resource. [From authors' abstract]

152. Loveless, C. M. 1959. A study of the vegetation in the Florida Everglades. Ecology 40:1–9.

The importance of fire and its influence on the vegetation of the Everglades is emphasized. The fire-tolerance of present-day vegetation is indicative of the frequency of natural fires. Fire during dry periods could dramatically alter physical and floral features of the Everglades; in wet years there is little noticeable effect. Ill conceived drainage has exacerbated the effect of fire. [K–L–S]

153. Lutz, H. J. 1956. Ecological effects of forest fires in the interior of Alaska. U.S. For. Serv. Tech. Bull. 1133. 121 pp.

This is a valuable historical review of what was known of fire relations in interior Alaska by the mid-1950's. Hydrology of much of Alaska was unknown at that time, but fire was noted to increase runoff and to increase amplitude between high and low water stages in rivers. Watersheds with steep slopes from which

vegetation had been removed by fire were generally noted to have very low minimum discharge rates and accelerated runoff. All aspects of fire interaction with taiga and tundra are reviewed. [K–L–S]

154. Lynch, J. J. 1941. The place of burning in management of the Gulf coast wildlife refuges. J. Wildl. Manage. 5:454–457.

Burning is an effective and practical tool in the management of Gulf coast National Wildlife Refuge wetlands. Marsh fires fall into three classes: cover burns (which may be either clean or spotty); root burns; and deep peat burns. Burning may serve one or more of the following functions: improvement of waterfowl habitat; promotion of waterfowl and muskrat food production and availability; protection from accidental or illegal fires; and facilitation of muskrat trapping. Cover burning, properly done, does not destroy valuable wildlife species, and the inevitable loss of wildlife in root or peat burns is more than offset by improvement of habitat and later gain in the wildlife population. Further experimentation is necessary before Gulf coast results can be adopted in other parts of the United States. [From author's abstract]

155. Lynch, J. J., T. O'Neil, and D. W. Lay. 1947. Management significance of damage by geese and muskrats to Gulf coast marshes. J. Wildl. Manage. 11:50–76.

Marsh damage known as "eatouts" result as a normal consequence of intensive feeding by snow geese and overpopulation of muskrats. Although some results of this damage may be beneficial, in general, profitable marsh management is hindered by eatouts. Goose eatouts are often quickly repaired by natural vegetation, but muskrat eatouts often produce worthless climax marsh. Complete eatouts occur on monospecific stands of preferred food plants. These may take years to recover. Partial eatouts occur when secondary and climax vegetation are equally abundant. Partial eatouts occurring on regularly burned marsh recover rapidly. However, those on unburned marsh result in cumulative damage that may take decades to rehabilitate. Muskrat eatouts are always inimical to profitable fur management; goose eatouts have greater wildlife value. Encouragement of goose eatouts within certain limits is thus appropriate management for wildlife refuges. Muskrat eatouts should not be encouraged in areas dedicated to wildlife management. [From author's abstract]

156. Lyon, L. J., H. S. Crawford, E. Czuhai, R. L. Fredricksen, R. F. Harlow, L. J. Metz, and H. A. Pearson. 1978. Effects of fire on fauna: a state-of-knowledge review. U.S. For. Serv. Gen. Tech. Rep. WO–6. 41 pp.

This paper summarizes Bendell (1974, q.v.) and adds material covering invertebrates and stream fauna. An attempt was made to recognize references published from 1974–78; 450 citations are listed. [K–L–S]

157. Mallik, A. V., and R. W. Wein. 1986. Response of a *Typha* marsh community to draining, flooding, and seasonal burning. Can. J. Bot. 64:2136–2143.

To inhibit the growth of cattails, a marsh should be drained and then burned in summer. Species richness is increased and cattail dominance decreased by this regime. Multiple burnings in summer remove a portion of the organic mat and release nutrients in the system. From the point of view of the wildlife manager, reduction in cattail cover is necessary to create the proper mix of open water and emergent vegetation. In the New Brunswick marsh studied, natural succession is toward nutritionally poor fens. Proper draining, burning, and reflooding arrests succession and maintains marsh productivity. [From authors' abstract]

158. Martin, A. C., R. C. Erickson, and J. H. Steenis. 1957. Improving duck marshes by weed control. U.S. Fish Wildl. Serv. Circ. 19-revised. 60 pp.

General guidelines for marsh weed control are provided with emphasis upon preventive planning, prompt action, selection of the best methods and season for treatment, and replacement of eliminated plants with useful species. Control by water level management, herbicides, mechanical methods, burning, and biological means are discussed. Burning is assessed as generally ineffective in control of

marsh weeds unless combined with some other method. Burning both before and after herbicidal treatment increases kill, and burning of tidal marshes at 1- to 3-year intervals controls bushy growth. [K–L–S]

159. Martin, R. E., H. E. Anderson, W. D. Boyer, J. H. Dieterich, S. N. Hirsch, V. J. Johnson, and W. H. McNab. 1979. Effects of fire on fuels: a state-of-knowledge review. U.S. For. Serv. Gen. Tech. Rep. WO–13. 64 pp.

A summary is provided of state-of-knowledge concerning direct and indirect effects of fires on fuels. Both wildfires and prescribed fires are considered. Fuel types and fire activity in six biogeographic regions are summarized. Major gaps in knowledge are identified as is recommended research to fill these gaps; 236 citations are listed. [K–L–S]

160. Martz, G. F. 1967. Effects of nesting cover removal on breeding puddle ducks. J. Wildl. Manage. 31:236–247.

During 1960–62 on Lower Souris National Wildlife Refuge, ND, there were 13% fewer puddle duck pairs on mowed and burned areas than where cover was untouched, but differences were not statistically significant. Overall, however, nest densities were greatest where residual cover was undisturbed. Mowing may have redistributed ducks, but regional water conditions may have been of most importance in determining the size of the local population. [From author's abstract]

161. Matta, J. F., and C. L. Clouse. 1972. The effect of periodic burning on marshland insect populations. Va. J. Sci. 23:113. (Abstract only)

Deliberate burning of coastal wetlands in Virginia is common, although ecological effects of this practice are largely unknown. Sweep net collections at 2-week intervals from 6 island sites representative of 4 burning situations at Back Bay National Wildlife Refuge, VA, indicated that the occurrence of the majority of adult forms found on the islands was not significantly affected by burning. The principal insect herbivore, a meadow katydid [*Conocephalus* sp. (Fam. Tettigoniidae)] did show significant differences in numbers between island sites, however, with fewer numbers at recently burned sites. [From authors' abstract]

162. McAtee, J. W. 1979. Ecology and management of gulf cordgrass [*Spartina spartinae* (Trin.) Hitch.] on the Texas Coastal Prairie. Ph.D. Dissertation. Texas A&M University, College Station. 209 pp.

[See McAtee et al. 1979*a*, 1979*b*.]

163. McAtee, J. W., C. J. Scifres, and D. L. Drawe. 1979*a*. Digestible energy and protein content of gulf cordgrass following burning or shredding. J. Range Manage. 32:376–378.

Digestible energy and crude protein content of green gulf cordgrass was significantly increased for 30 to 90 days after burning or shredding on Texas coastal prairie: digestible energy of 2,414 to 2,891 kcal/kg in regrowth on burned areas and from 1,879 to 2,602 kcal/kg on shredded areas compared to 1,612 to 1,917 kcal/kg in green leaves of plants from untreated areas; crude protein of 9% to 11% following burning or shredding compared to 4% to 5% in green plants from untreated areas. Both burning and shredding have potential for increasing the nutritional value of gulf cordgrass during the cool season when other green forages are scarce on the coastal prairie. The roughness of cordgrass range, its frequent inundation, and the cost of shredding make fire the most practical approach to cordgrass improvement. Season of burning is not critical as long as sufficient moisture is available for regrowth; fall or early winter burns appear most logical on the Texas coastal prairie. [From authors' abstract]

164. McAtee, J. W., C. J. Scifres, and D. L. Drawe. 1979*b*. Improvement of gulf cordgrass range with burning or shredding. J. Range Manage. 32:372–375.

Shredding or burning during spring, summer, or winter increased live gulf cordgrass standing crop, and increased the percentage of plants supporting inflorescences by the end of the first growing season after treatment on a clay site. Treatment resulted in less favorable response on a saline fine sand site, with shredding promoting relatively greater cordgrass production. Most favorable growth responses

resulted from spring treatment, presumably because subsequent rainfall was greater than that following summer treatments. Shredding generally stimulated herbaceous yields more than burning because shredding improved moisture relationships relative to the bare surface following fires. Both methods improve gulf cordgrass range for livestock grazing, but burning is the more economical alternative. [From authors' abstract]

165. McDaniel, S. T. 1966. A taxonomic revision of *Sarracenia* (Sarraceniaceae). Ph.D. Dissertation. The Florida State University, Tallahassee. 134 pp.

[See McDaniel 1971]

166. McDaniel, S. 1971. The genus *Sarracenia* (Sarraceniaceae). Tall Timbers Res. Stn. Bull. 9:1–36.

In the South, pitcherplants are well-adapted to moderate fires which remove old growth, destroy competition, and may induce flowering. Moderate fire was historically a natural feature of the bog habitat of pitcherplants, but in the present century, moderate fires have become less frequent. Severe fire, timber clearing, agriculture, and other man-related activities have changed pitcherplant habitat. Prevention of moderate, beneficial fire favors occasional severe wildfires in resultant heavy undergrowth. Such wildfires and other disturbances apparently permit the subsequent establishment of hybrid pitcherplants which may persist for years through vegetative reproduction until overcome by competition from parental forms. [K–L–S]

167. McKinley, C. E., and F. P. Day, Jr. 1979. Herbaceous production in cut-burned, uncut-burned, and control areas of a *Chamaecyparis thyoides* (L.) BSP (Cupressaceae) stand in the Great Dismal Swamp. Bull. Torrey Bot. Club 106:20–28.

The cut-burned area of Atlantic white-cedar had the highest productivity (3,475 kg/ha/yr) and was characterized by species of Asteraceae, Poaceae, and Cyperaceae. The uncut-burned area had a productivity of 1,636 kg/ha/yr with species of the Asteraceae but lacking the grasses and sedges. The control area had the lowest productivity (365 kg/ha/yr) and had few herbaceous species. Fire opened the overstory and thereby increased production, influenced species composition of vegetation, and stimulated regeneration of Atlantic white-cedar. [From authors' abstract]

168. McNab, W. H., R. W. Johansen, and W. B. Flanner. 1979. Cold winter and spring extended fire season in the pocosins. Fire Manage. Notes 40(4):11–12.

Frost kill of the previous year's pocosin vegetation added to the usually heavy load of flashy, dead fuels in North Carolina. Kill of all new, succulent spring growth of many plants in areas lacking a pine overstory added to the problem. Water levels in 1977 were at least 46 cm below normal in pocosins sampled. The result was that the normal end of the fire season (May 20) was not obtained, fire–spread in pocosin fuels continued to be rapid, and fire danger remained abnormally high. [From authors' abstract]

169. McNease, L .L. 1967. Experimental treatments for the control of wiregrass and saltmarsh grass. M.S. Thesis. Louisiana State University, Baton Rouge. 72 pp.

[See McNease and Glasgow 1970]

170. McNease, L. L., and L. L. Glasgow. 1970. Experimental treatments for the control of wiregrass and saltmarsh grass in a brackish marsh. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 24:127–145.

A study to evaluate the effects of treatments designed to alter natural plant succession in marshhay cordgrass and seashore saltgrass plant communities and improve the vegetative composition for wildlife was conducted at the Rockefeller Refuge in Louisiana. Tilling; burning and tilling; and burning, tilling, and use of chemicals were most effective in reducing the growth of undesirable vegetation and in promoting the growth of a more desirable species, widgeongrass. Re-invasion by desirable species of bulrush was nil after 5 years. Chemicals and combinations of burning and chemicals gave good short-term control. However, after 1 year, the percent kill dropped off appreciably. Fire breaks

constructed by a rotary tiller were able to contain all seven of the fires tested in this investigation. [From authors' abstract]

171. Means, D. B., and P. E. Molar. 1978. The Pine Barrens treefrog: fire, seepage bogs, and management implications. Pages 77–83 *in* R. R. Odum and L. Landers, eds. Proceedings of the rare and endangered wildlife symposium. 3-4 August 1978, Athens, GA. Ga. Dep. Nat. Resour. Game Fish Div. Tech. Bull. WL4.

The size of local breeding choruses of the Pine Barrens treefrog correlates with the amount and quantity of larval, seepage habitat (grass-sedge-herb bog) at a site. Periodic natural fires are important in maintaining bogs by killing encroaching woody vegetation. Natural fires in the range of this amphibian are either actively suppressed or impeded by roads and other human alterations of the landscape. The proper use of prescribed burning will be necessary to maintain the aquatic seepage bogs that larvae need. [From authors' abstract]

172. Messinger, R. D. 1974. Effects of controlled burning on waterfowl nesting habitat in northwest Iowa. M.S. Thesis. Iowa State University, Ames. 49 pp.

Vegetative changes associated with early spring burning were not sufficient to greatly alter waterfowl utilization for nesting during the first year postburn. Plant richness increased after burning, but frequency of the species varied inconsistently. Live weight of vegetation increased after the burns, but results were confounded by abnormally high precipitation. In general, nest success was low on the burned plots, probably because of reduced litter which resulted in increased predation rates. Nests were associated with tall heights and greater coverage of vegetation, but not density. Successful nests, however, were found in taller vegetation and greater coverages. [From author's abstract]

173. Millar, J. B. 1973. Vegetation changes in shallow marsh wetlands under improving moisture regime. Can. J. Bot. 51:1443–1457.
Greater than normal spring water depths decreased densities of most shallow marsh emergents; two or more growing seasons with continuous flooding eliminated emergent cover. Similarly, two or more autumn floods likewise destroyed emergents. Neither mowing nor burning changed species composition, but cultivation and grazing had significant effects on a Saskatchewan marsh. Use of basin size and depth criteria to evaluate wetland habitat value for waterfowl is illustrated. [From author's abstract]

174. Miller, A. W. 1962. Waterfowl habitat improvement in California. Proc. Annu. Conf. Western Assoc. Fish Game Comm. 42:112–116.

Means to keep marsh vegetation in subclimax state include drainage and reflooding, cultivation, water level manipulation, changing salinity or alkalinity, burning, chemical control, and biological control. Examples are given of use of each management practice and its value in favoring development of waterfowl food plants. A primary use of fire in California is to reduce accumulation of vegetative debris. [K–L–S]

175. Miller, H. A. 1963. Use of fire in wildlife management. Proc. Annu. Tall Timbers Fire Ecol. Conf. 2:19–30.

Burning in the Horicon marshes in Wisconsin improves waterfowl food supplies and encourages development of needed potholes through peat burns. It also retards the displacement of herbaceous marsh plants by willow-alder brush, which is a poor waterfowl habitat. [K–L–S]

176. Monk, C. D. 1968. Successional and environmental relationships of the forest vegetation of north central Florida. Am. Midl. Nat. 79:441–457.

Southern mixed hardwoods, mixed hardwood swamps, bayheads, sand pine scrub, sandhills, pine flatwoods, and cypress heads are the major forest community types in north central Florida. The first three are climax (on upland, wet fertile, and wet acid sites, respectively) and the latter four are successional. With improved drainage or the elimination of fire, successsion may proceed in various directions. Details are provided for the successional sequences defined. [From author's abstract]

177. Moss, E. H. 1953. Marsh and bog vegeta-

tion in northwestern Alberta. Can. J. Bot. 31:448–470.

Swamp, marsh, wet meadow, saline meadow, *Drepanocladus* bog, and *Sphagnum* bog are characterized, and related aquatic vegetation is described briefly. Retrogression caused by burning is described for marshes, bogs, and bog forests. [From author's abstract]

178. Munaut, A. V. 1976. Paysages vegetaux de la Floride meridionale. [Plant landscapes of southern Florida.] Nat. Belg. 57:73–99.

An ecological description of southern Florida flora, fauna, geography, and history is provided. Current problems with unnatural fire regimes and subsequent effects upon the vegetation communities are discussed as are problems with decreasing water supply, especially as they relate to Everglades National Park. Comparisons are drawn between present south Florida vegetation and the vegetation of western Europe at the end of the Tertiary. [K–L–S]

179. Myers, K. E. 1955. Management of needlerush marsh at the Chassahowitzka Refuge. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 9:175–177.

Management methods for controlling needle rush at Chassahowitzka National Wildlife Refuge, FL, include mowing, disking, spraying, burning, or combinations of two or more procedures. Needle rush is generally regarded as a weed because it produces little seed for wildlife food, although it does have some value as cover. Burning in early spring increased a useful, competing subdominant, Olney bulrush. It also made mowing operations easier. However, it was only effective if used in conjunction with mowing and herbicide spraying. [K–L–S]

180. Neckles, H. A., J. W. Nelson, and R. L. Pedersen. 1985. Management of whitetop (*Scolochloa festucacea*) marshes for livestock forage and wildlife. Delta Waterfowl Res. Stn. (Portage la Prairie, MB) Tech. Bull. 1. 12 pp.

Removal of excess plant litter by either light grazing, mowing, or burning is a major management approach for developing high-yield monodominant whitetop rivergrass stands. This vegetation provides excellent forage as well as nesting and brood-rearing cover and substrate for invertebrates necessary to female and young waterfowl. If flooded during spring, burned whitetop basins yield 55% more forage than unburned stands [up to 15,080 kg/ha (13,460 lb/acre)] . Burning is not recommended where a water source is lacking because winter snow catchment and subsequent spring flooding are reduced by removal of stubble and residual growth. Suggested grazing, haying, and burning programs to simultaneously maximize forage yield and enhance waterfowl production are provided. [K–L–S]

181. Neely, W. W. 1962. Saline soils and brackish waters in management of wildlife, fish, and shrimp. Trans. N. Am. Wildl. Conf. 27:321–335.

Late summer burning is suggested as a management practice for marshhay cordgrass to permit growth of green stems preferred by geese. Rotational burning of fields within and between years provides the best conditions. [K–L–S]

182. Nelson, N. F., and R. H. Dietz. 1966. Cattail control methods in Utah. Utah Dep. Fish Game Publ. 66–2. 31 pp.

Cultivation killed cattail on areas where the soil could be dried and foliage burned prior to tillage. Fire alone killed cattail where foliage was removed to ground level and the stems remained flooded after fire. Fall spraying of Dalapon was effective, but did not provide complete control. Various explosives also may be used to blast openings in cattail. Crushing is the least expensive means of control; aerial spraying with Dalapon is the second least costly. Water control remains the key to cattail control. Drying alone can kill cattail in one season if root stocks are killed by discing or tilling, or in 2 years of drought without discing. In areas that cannot be dried, any reduction of water levels after cut, crushed, or burned stems are reflooded will result in re-establishment of cattail seedlings. Although benefits from cattail control can be immediate and positive for waterfowl and other marsh wildlife, assessment of costs and benefits should precede

all large-scale control efforts. [From authors' abstract]

183. Niering, W. A. 1981. The role of fire management in altering ecosystems. Pages 489–510 *in* H. A. Mooney, T. M. Bonnicksen, N. L. Christensen, J. E. Lotan, and W. A. Reiners, tech. coords. Proceedings of the conference: fire regimes and ecosystem properties. 11-15 December 1978, Honolulu, HI. U.S. For. Serv. Gen. Tech. Rep. WO-26.

The use of prescribed burning to benefit wildlife, forest, and range management, and to maintain biotic diversity is discussed with examples. The benefits for game birds, big game, and waterfowl are emphasized. Although most species benefit from habitat disturbance, knowledge of total ecosystem response, especially with regard to nongame populations, is limited. A holistic view must be maintained in which fire is viewed in perspective with the complex of other synergistic factors operative in maintaining ecosystem stability and diversity. [K–L–S]

184. Oefinger, R. D., and C. J. Scifres. 1977. Gulf cordgrass production, utilization, and nutritional value following burning. Tex. Agric. Exper. Stn. Bull. GB-1176. 19 pp.

Trends for gulf cordgrass herbage production were similar across five sites although burning date varied. During periods of adequate soil moisture, herbage production postburn was greatly enhanced, but the rate of recovery was highly dependent upon site characteristics. The extent of utilization of cordgrass by livestock is regulated by date of burn and site characteristics, but availability of alternative forages also reduced use. Nutrient content of gulf cordgrass herbage decreased as the percentages of old growth increased at each site. Digestible energy of cordgrass following burning may attain almost 2,800 kcal/kg. Burning in the early fall allowed cordgrass regrowth for cattle throughout winter when other range forages were dormant and provided sufficient protein through early spring, when cattle switched to other forages. Range sites with ample soil moisture and nutrients are optimum for use of burning as an improvement tool. Saline sites not conducive to growth of other vegetation are also suitable for burning. [K–L–S]

185. O'Neil, T. 1949. The muskrat in the Louisiana coastal marshes. Fed. Aid Sec., Fish Game Comm., La. Dep. Wildl. Fish., New Orleans, LA. 152 pp.

Results are presented from a study on the ecology, population trends, food habits, and management of muskrats in Louisiana coastal marshes. As a management tool, prescribed burning: (1) prevents accumulation of "rough," which if accidentally ignited can do considerable habitat damage; (2) opens up dense vegetation, attracting waterfowl and making marsh travel easier; and (3) sets back succession so that preferred food species such as Olney bulrush can grow. The successional sequence following a deep, peat burn in a sawgrass marsh is described. [K–L–S]

186. Opler, P. A. 1981. Management of prairie habitats for insect conservation. J. Nat. Areas Assoc. 1(4):3–6.

Prairie invertebrates, particularly insects, have been neglected in conservation efforts. The most seriously reduced insect populations occur in the tallgrass prairie province, particularly those found in wet prairie. Burning and mowing are management techniques necessary for maintenance of prairie vegetation, but burning can destroy insect populations. Reserve areas should therefore be divided into several separate compartments which should take into account microgeographic variation, and burning should be on a rotating schedule. [K–L–S]

187. Palmisano, A. W., Jr. 1967. Ecology of *Scirpus olneyi* and *Scirpus robustus* in Louisiana coastal marshes. M.S. thesis. Louisiana State University, Baton Rouge. 145 pp.

Factors affecting the establishment, growth, and propagation of Olney bulrush and saltmarsh bulrush were studied in Louisiana coastal marsh. Olney bulrush was associated with shallow water, total salts of 10,000 to 17,000 ppm, and pH of 4.1 to 7.9. Saltmarsh bulrush tolerated high salinity (12,000 to 22,000 ppm) and more fluctuation in water level

(–15.2 to +12.7 cm). Both were dormant in winter. Olney bulrush flowered and set seed by early July, but seed production was only 0.00 to 11.07 kg/ha. Saltmarsh bulrush flowered later and seed did not mature until August. Production ranged from 880 to 2100 kg/ha. Marsh fire stimulated germination slightly. [From author's abstract]

188. Penfound, W. T. 1952. Southern swamps and marshes. Bot. Rev. 18:413–446.

Fire is identified as a major agent of plant community change in this review of southern wetlands. Some marshes are dependent upon fire for formation (shallow freshwater marshes on deep soil), or for maintenance (grass-sedge bogs—savannahs). Burning is relatively unimportant in alluvial plains, but may be severe in both swamps and marshes during drought. Purposely set fires are used to maintain vegetation communities preferred by muskrats in coastal marshes. [K–L–S]

189. Penfound, W. T., and E. S. Hathaway. 1938. Plant communities in the marshland of southeastern Louisiana. Ecol. Monogr. 8:1–56.

Fire is an important influence in southeastern Louisiana marshes. Muskrat trappers fire the marshes to ease access and to remove marshhay cordgrass and encourage saltmarsh bulrush and Olney bulrush, preferred muskrat foods. Fire removes debris and thus impedes marsh accretion. In marshes partially drained by canals, fires in the dry season can destroy major portions of the 30 to 91 cm thick peaty humus, greatly lowering the marsh. A more hydric community results. Only if fired when the soil is wet and there is no wind can a fire hazard (the debris) be removed without damaging the marsh. This paper provides a good review of plant communities, edaphic factors, and phenology of these coastal marshes. [K–L–S]

190. Perkins, C. J. 1968. Controlled burning in the management of muskrats and waterfowl in Louisiana coastal marshes. Proc. Annu. Tall Timbers Fire Ecol. Conf. 8:269–280.

The types of marshes occurring along the Louisiana coast, the vegetation present, and the role of fire in maintaining this vegetation for marsh and waterfowl management are described. Late September to January burns attract snow geese. Fire causes muskrats to disperse, thereby facilitating trapping. Burns in early October, before construction of muskrat houses, are desirable. Burning is necessary to maintain Olney bulrush, a preferred muskrat food, which otherwise would be replaced by marshhay cordgrass. [K–L–S]

191. Plummer, G. L. 1963. Soils of the pitcher plant habitats in the Georgia coastal plain. Ecology 44:727–734.

The overall levels of nutrients in the moist pine barrens of Georgia seem incapable of supporting the dense plant biomass. Reasons for this seeming incongruity may include the slow decomposition of pitcher plant and grass (threeawn) litter and thus a gradual release of nutrients, a rapid recycling of available minerals including some release by fires, intrinsic conservation mechanisms of the perennial plants, and an influx of nutrients with soil water. In contrast, soil nutrients in the intermediate pine barrens seem sufficient to support the existing vegetation, but here, water is the limiting factor. During the first growing season following fire, productivity is high. Without additional fire, in the succeeding years productivity drops to 50% of that following fire. Despite high organic content, the soils are not very productive unless nutrients are released in quantity, as by fire. [K–L–S]

192. Pullen, T., Jr., and G. L. Plummer. 1964. Floristic changes within pitcher plant habitats in Georgia. Rhodora 66:375–381.

A comparison of the flora in the moist barrens of Georgia in 1906 with that of 1962 showed an introduction of 98 new occurrences and the elimination of perhaps 50 species. These floristic changes seem entirely related to changes in land use, namely management of these lands for intensified grazing. Coincidental with grazing is annual burning, the import of new species through winter supplement of hay for cattle, and increased vehicular traffic. Fire and pasture development have provided optimum conditions for the most heliotypic species through release of nutrients and removal of litter. [K–L–S]

193. Putnam, J. A. 1951. Management of bottomland hardwoods. U.S. For. Serv. South. For. Exp. Stn. Occas. Pap. 116. 60 pp.

Elements of an effective fire protection system must be addressed in bottomlands management. Fire history, areas of greatest hazard, effectiveness of natural barriers, availability of manpower, equipment needs, and potential cooperators must be identified. Every 5 to 8 years, a serious fire season occurs, when ground and surface fires cause great damage. Fire in bottomlands moves rapidly, consuming shrubs and weeds, and killing all tree reproduction under 10 years. Bark is scorched on larger trees, leading to entry points for stain, rot, and insects. A fire once every 10 years thus eliminates the possibility of intensive forest management. With the exception of a dry, early spring, fall is the fire season. Dangerous years are those when usual summer drought extends into autumn and early winter. It is important to increase fire consciousness of surrounding landowners and the public. Additionally, firebreaks plowed annually late in the growing season are desirable, and air and ground patrol during the fire season are necessary. Suppression of fires in bottomlands follows standard techniques except that building a fire line in unusually difficult in the heavy vegetation, packed soil, and extensive root systems. [K–L–S]

194. Reilly, J. R. 1948. A study of the metazoal parasites of the Maine muskrat (*Ondatra zibethica zibethica* (Linnaeus, 1758)). M.S. Thesis. University of Maine, Orono. 59 pp.

[See Reilly 1949]

195. Reilly, J. R. 1949. A study of the metazoal parasites of the Maine muskrat (*Ondatra zibethica zibethica* Linnaeus, 1758). J. For. 47:391. (Abstract only)

This citation abstracts a Masters thesis (Univ. Maine, 1948) in which trematodes, cestodes, nematodes, and mites of 126 muskrats were reported. Disease control through burning and water level maintenance was suggested. [K–L–S]

196. Richardson, C. J., editor. 1981. Pocosin wetlands: and integrated analysis of coastal plain freshwater bogs in North Carolina. Hutchinson Ross Publ. Co., Stroudsburg, PA. 364 pp.

This proceedings of a 1980 conference provides 23 papers on the history of development of pocosins; their resource ecology; nonindustrial and industrial values; peat, timber, and natural resource economics; law and policy for management; and a critique of the entire symposium. Fires, especially man-caused fires associated with drainage, have extremely detrimental effects upon pososins. Natural fires, however, are necessary to the maintenance of seral pocosin vegetation. Two papers that address fire–wetlands relations in detail within this symposium are included in this bibliography (Christensen et al. 1981; Richardson et al. 1981). [K–L–S]

197. Richardson, C. J. 1983. Pocosins: vanishing wastelands or valuable wetlands? BioScience 33:626–633.

By 1980, extensive drainage for agriculture, forestry, and peat mining in North Carolina had reduced pocosins from nearly 1 million ha to 281,000 ha. As a result, hydrologic output has shifted from evapotranspiration to runoff, carbon flux has increased; P, Ca, and K loss has occurred; habitat has been reduced for endangered species; and the economic value of the remaining lands has dramatically increased. Fire has always been of importance in peatlands, but extensive fires that remove the peat substrate revert the pocosin to swamp forest. Such natural events, coupled with anthropogenic development, threaten the remaining habitat. Additional detrimental effects of pocosin alteration are illustrated, and suggestions for means to develop true estimates of pocosin values are provided. [K–L–S]

198. Richardson, C. J., R. Evans, and D. Carr. 1981. Pocosins: an ecosystem in transition. Pages 3–19 *in* C. J. Richardson, ed. Pocosin wetlands: an integrated analysis of coastal plain freshwater bogs in North Carolina. Hutchinson Ross Publ. Co., Stroudsburg, PA.

Major users of pocosin lands drain, burn, and carry out extensive site preparation. This has resulted in a loss of 70% of the pocosins in North Carolina. In 1979, 33% of pocosins

surveyed were totally developed, 36% were under partial or potential development status, and only 31% remained in their natural state. The transfer of nearly 202,000 ha since 1962 to large corporate farm operations is the greatest change in land ownership affecting pocosins. For resource managers to develop appropriate management guidelines for the remaining pocosins, an integrated analysis of the resource must be completed. [From authors' abstract]

199. Robertson, W. B. 1954. Everglades fires—past, present, and future. Everglades Nat. Hist. 2:11–16.

Fire is a natural ecological factor in south Florida, responsible for the maintenance of the mosaic of pinelands and sawgrass in the Everglades. Under present conditions, which involve substantial drainage and lowering of the water table, fire is potentially capable of eliminating inland hardwood forests, causing floristic impoverishment, and producing other degenerative changes. Thus, fire suppression must be increasingly efficient if the glades are to be maintained. Without return of higher water levels, increased consideration must be given to understanding the role of fire and the wisest ways to manage fire in south Florida. [K–L–S]

200. Robertson, W. B. 1962. Fire and vegetation in the Everglades. Proc. Annu. Tall Timbers Fire Ecol. Conf. 1:67–80.

The mosaic pattern of southern Florida vegetation cannot be explained on the basis of variations in soils or climate. Fires and hurricanes are viewed as major natural forces affecting the ecosystem. At the time this paper was published, the historic and recent importance of fire was just beginning to be recognized in the Everglades system. [K–L–S]

201. Ross, W. M. 1970. Methods of establishing natural and artificial stands of *Scirpus olneyi*. M.S. Thesis. Louisiana State University, Baton Rouge. 99 pp.

[See Ross and Chabreck 1972]

202. Ross, W. M., and R. H. Chabreck. 1972. Factors affecting the growth and survival of natural and planted stands of *Scirpus olneyi*. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 26:178–188.

Burning, tilling, and a combination of burning and tilling were tested as a means of site preparation for Olney bulrush at Rockefeller Refuge and Ben Hur Experiment Station, LA. Tilling alone was the best method for site preparation; burning alone was the worst; and a combination of the two gave intermediate results. Nonetheless, survival in the burned area was almost twice that in the area with no soil preparation. Since tilling is not always possible, some combination of burning and chemical control appears to be the best site preparation technique for this bulrush. After establishment, water level has the greatest effect upon growth and survival. Best results were obtained in 5 to 9 cm of water. [K–L–S]

203. Rowe, J. S., and G. W. Scotter. 1973. Fire in the boreal forest. Quat. Res. (NY) 3:444–464.

The boreal forest in North America owes much of its floristic and faunistic diversity to periodic fires ignited by lightning and man. Fire is shown to exert a significant effect upon vegetational composition, soil chemical properties and the soil thermal regime, and on animal populations through the particular mosaic of habitats created. [From authors' abstract]

204. Rutkosky, F. W. 1978. Bibliography on the effects of prescribed burning and mammal and waterfowl utilization of wetlands: annotated literature search with selected abstracts. U.S. Fish Wildl. Serv., Div. Ecol. Serv., Annapolis Field Office, Annapolis, MD. 45 pp. [Available in the U.S. Dep. Int. Nat. Resour. Library, Washington, D.C. 20240]

This bibliography contains 176 entries, 47 of which are abstracted. An index lists entries under the topics of fire, mammals, management, prescribed burning, *Scirpus olneyi*, waterfowl, and wildlife foods. Some dissertations and foreign publications are included. [K–L–S]

205. Ryan, M. R. 1982. Marbled godwit habitat selection in the northern prairie region. Ph.D. Dissertation. Iowa State University, Ames. 108 pp.

[See Ryan et al. 1984]

206. Ryan, M. R., R. B. Renken, and J. J. Dinsmore. 1984. Marbled godwit habitat selection in the northern prairie region. J. Wildl. Manage. 48:1206–1218.

Marbled godwit wetland and upland habitat use and selection in east-central North Dakota showed preference for short, sparse to moderately vegetated sites and open water or bare soil along wetland shorelines. Data are presented for age/sex and seasonal habitat selection. The authors recommend an ecosystem level management approach that incorporates the preservation of wetland complexes (including less permanent pond types and alkali wetlands) and the use of fire, mowing, and grazing on portions of publicly managed lands to recreate the shorter grass "disturbed" habitats of the pristine northern prairies to which marbled godwits and other wildlife are adapted. [From authors' abstract]

207. Samson, F. B. 1980. Use of montane meadows by birds. Pages 113–129 *in* R. M. DeGraff, tech. coord. Workshop proceedings: management of western forests and grasslands for nongame birds. 11-14 February 1980, Salt Lake City, UT. U.S. For. Serv. Gen. Tech. Rep. INT-86.

Montane meadows serve as important foraging areas for avian communities associated with nearby riparian or forest habitats. Care should be exercised in grazing and other land-use prescriptions such as fire because of their accelerative effect upon meadow succession. Both permit invasion of conifers and ultimately meadow loss. [From author's abstract]

208. Sandberg, D. V., J. M. Pierovich, D. G. Fox, and E. W. Ross. 1979. Effects of fire on air: a state-of-knowledge review. U.S. For. Serv. Gen. Tech. Rep. WO-9. 40 pp.

A summary of the effects of forest burning on the air and a listing of high priority research questions for the management of smoke from prescribed and wild fires is provided; 102 citations are listed. [K–L–S]

209. Sanderson, G. C., and F. C. Bellrose. 1969. Wildlife habitat management of wetlands. An. Acad. Bras. Cienc. 41 (suppl.):153–204.

This comprehensive review addresses North American wetland distribution, abundance, classification, preservation, value, and management. Water control, vegetation control, and animal control are discussed in detail; burning is listed as a major habitat improvement tool. Types of burns are summarized. The burning of over 404,700 ha per year in management of fresh, brackish, and salt marshes of the south Atlantic and Gulf coasts is emphasized. [K–L–S]

210. Schlesinger, W. H. 1976. Biogeochemical limits on two levels of plant community organization in the cypress forest of Okefenokee Swamp. Ph.D. Dissertation. Cornell University, Ithaca, NY. 142 pp.

Aspects of community structure and nutrient circulation are described for the pondcypress forest of Okefenokee Swamp, Georgia, and for the epiphyte Spanish moss. The tree stratum is nearly a monoculture, probably because of recurrent understory fires that destroy competitors. Differences in stand density are due to past differences in fire frequency. Above-water biomass has been maintained at a constant level by fire-induced thinning. Shrubs are still in the process of regenerating following a 1954–55 fire. [From author's abstract]

211. Schlesinger, W. H. 1978*a*. Community structure, dynamics and nutrient cycling in the Okefenokee cypress swamp-forest. Ecol. Monogr. 48:43–65.

The tree stratum of Okefenokee is dominated by pondcypress, probably because of recurrent understory fires that eliminate other swamp species. Abundant standing dead trees suggest that differences in density among stands are due to past differences in the frequency and intensity of fires during periodic drought. In recent years, above-water biomass has been maintained at a constant level by fire-induced thinning. Relatively high shrub productivity may be maintained by periodic fires. [From author's abstract]

212. Schlesinger, W. H. 1978*b*. On the relative

dominance of shrubs in Okefenokee Swamp. Am. Nat. 112:949–954.

Fires, high light availability, and a long growing season probably contribute to the high levels of net productivity (106g/m^2/yr) in the Okefenokee shrub stratum. Fires are periodically common, occurring during drought. [K–L–S]

213. Schlichtemeier, G. 1967. Marsh burning for waterfowl. Proc. Annu. Tall Timbers Fire Ecol. Conf. 6:40–46.

This study sought to determine whether burning, along with other related habitat manipulation methods, would help to restore for waterfowl use a common reed-choked marsh in north-central Nebraska. Dense stands could be burned readily when ice was 23 to 30 cm thick and 5 to 10 cm of snow covered the surrounding range, preventing ignition of organic soils. Light or moderate grass fuels would not burn under similar conditions. Winter burning reduced common reed and bulrush density 60% to 85%, allowing space for waterfowl movement and activities during summer and fall. [K–L–S]

214. Schnell, D. E. 1976. Carnivorous plants of the United States and Canada. John F. Blair, Winston Salem, NC. 125 pp.

The control of fire and water levels in the bog wetland habitat of these plants are the most detrimental anthropogenic actions at present. Fast surface fires in bogs remove detritus, competing herbs, and young woody plants that invade the bog margin. Periodic autumn firing, properly controlled, can prolong the life of a bog by setting back normal succession to a forest in the north and to a scrub bog in the south. Although fire is a natural phenomenon in bogs, hot, deep and thus destructive fires, especially after initiating drainage, destroy bogs entirely. The urgency of bog conservation is emphasized. [K–L–S]

215. Schnell, D. E. 1982. Effects of simultaneous draining and brush cutting on a *Sarracenia* L. population in a southeastern North Carolina pocosin. Castanea 47:248–260.

Cutting, burning, and ditching of a large pocosin dramatically affected pitcherplant and shrub species. Prior to disturbance, pitcherplants of three species were growing poorly but maintaining a presence in absence of fire for 20 years. Subsequent to clearing and burning, pitcherplants were released and became dominant and there was an increase in seedling activity. The primary value of clearing and/or burning appears to be release from competition. The effects of ditching lagged, but with soil drying 1–2 years after clearing, pitcherplants promptly decreased even though shrubs had not resprouted sufficiently to provide competition. In comparison with savanna burns, the same factor—release from competition for light and space—seems to be the key in pitcherplant rebound following disturbance. [K–L–S]

216. Schnick, R. A., J. M. Morton, J. C. Mochalski, and J. T. Beall. 1982. Mitigation and enhancement techniques for the Upper Mississippi River system and other large river systems. U.S. Fish Wildl. Serv., Resour. Publ. 149. 714 pp.

This guide provides a review of techniques that can reduce or eliminate man's negative impact on large river systems. Discussion for each technique or group of techniques includes: (1) the situation to be mitigated or enhanced; (2) a description of the technique; (3) impacts on the environment; (4) costs; and (5) appropriateness of use on the Upper Mississippi River. Included are bank stabilization techniques, dredging and disposal of dredged material, fishery management techniques, and wildlife management techniques. The use of fire in habitat management is discussed in context with other techniques found valuable in lands adjacent to large river systems. [This text provides an excellent basic reference for wetland managers.] [From authors' abstract]

217. Scifres, C. J., and D. L. Drawe. 1980. Gulf cordgrass: distribution, ecology and responses to prescribed burning. Pages 83–92 *in* C. W. Hanselka, ed. Prescribed range burning in the coastal prairie and eastern Rio Grande plains of Texas. Proceeding of a Symposium held 16 October, 1980. Tex. Agric. Exten. Serv., Texas A&M University, College Station.

Gulf cordgrass forms almost pure stands at

elevations intermediate between lowland marshes and upland coastal prairie, and requires inundation alternating with dry periods for maximum stand development. Gulf cordgrass is well adapted to fire. Periodic prescribed burning removes excessive mulch and rejuvenates stands. Large, decadent gulf cordgrass bunches are replaced by several smaller, but vigorous, plant units following fire, and production of inflorescences is increased. Mature gulf cordgrass is unpalatable and not grazed to any appreciable extent by domestic livestock. Burning at any season, given adequate stored soil water to permit regrowth, will stimulate grazing by cattle. New growth is higher in crude protein, phosphorus, and digestible energy content than mature herbage. Gulf cordgrass has considerable potential for filling the cool-season forage gap on the coastal prairie. [From authors' abstract]

218. Sharitz, R. R., and J. W. Gibbons. 1982. The ecology of southeastern shrub bogs (pocosins) and Carolina bays: a community profile. U.S. Fish Wildl. Serv., FWS/OBS-82/04. 93 pp.

Pocosins and Carolina bays, shrub bogs of the Carolinas and Georgia, share roughly the same distribution patterns, soil types, floral and faunal species composition, and other community attributes, but differ in geological formation. Pocosin vegetation is part of a complex successional sequence of communities that may be controlled by fire, hydroperiod, soil type, and peat depth. Physical and chemical characteristics, biological features, the influence of human activity, and recommendations for conservation, preservation, and management of these wetlands are presented in detail. Throughout, the integral role of fire in these communities is recognized. The effects and long–term consequences of fire in shrub bogs are poorly known, even though some ecological impacts are apparent. The effects of prescribed burning, used largely to prevent wildfire and to prepare sites for other management activities, are completely unknown. Basic research on fire effects, particularly its relationship to community productivity and elemental cycling, are needed. [K–L–S]

219. Shay, J. M., D. J. Thompson, and C. T. Shay. 1987. Post-fire performance of *Phragmites australis* (Cav.) Trin. in the Delta Marsh, Manitoba. Arch. Hydrobiol. Beih. 27:95–103.

Common reed recovery of aboveground biomass, shoot density, and mean shoot weight were evaluated for 4 years following summer, fall, and spring burns. Biomass the year following summer burns was substantially reduced; biomass was enhanced following spring and fall burns. Shoot density increased in all treatments although average weight per stem was less than half pre-burn levels. After 4 years, all values approached those on control plots. Probable reasons for these responses are discussed. [From authors' abstract]

220. Shepherd, W. O., and E. U. Dillard. 1953. Best grazing rates for beef production on cane range. N.C. Agric. Exp. Stn. Bull. 384. 23 pp.

Cane range in Washington County, NC, can produce 4,482 kg dry weight of edible herbage/ha/year (2 tons/acre/year). On 6 experimental ranges, 55% to 60% utilization was the maximum degree of permissible summer grazing to produce sustained yields of forage and beef. This was equivalent to 1.1 ha (2.8 acres)/cow and calf for the 6.5–7 month grazing season. Reduction in fire hazard of the cane was roughly proportional to the degree of grazing. Continued heavy grazing will kill cane and allow replacement by more flammable weeds. Regrowth of cane is prompt after spring burns. Fall burns after summer drought destroy cane stands by removing peat down to the water table. [K–L–S]

221. Shepherd, W. O., E. U. Dillard, and H. L. Lucas. 1951. Grazing and fire influences in pond pine forests. N.C. Agric. Exp. Stn. Tech. Bull. 97. [57 pp.]

Cane is an important forage and a constituent of the pond pine forest found in coastal plain lowlands. On experimental sites at the edge of a pocosin, protection from grazing favored cane in competition from shrubs following fire. Burning, however, increased cane susceptibility to grazing damage. Disturbance of litter by grazing favored establishment and growth of pond pine seedlings; fire may be essential to regenerate pond pine stands. Wildfire burns increased cattle gains during the year of the

fire, but depleted the forage stand and decreased gains in the subsequent year. Range deterioration was pronounced under heavy stocking. [From authors' abstract]

222. Sidle, J. G. 1981. Wetland easements and their enforcement in North Dakota. Wildl. Soc. Bull. 9:273–279.

Sixteen years of wetland easement enforcement data, collected on the Arrowwood Wetland Management District, showed that drainage was the most common violation. Thirty-five filling violations and 220 burning violations were also recorded. [From author's abstract]

223. Simms, E. L. 1983. The growth, reproduction, and nutrient dynamics of two pocosin shrubs, the evergreen *Lyonia lucida* and the deciduous *Zenobia pulverulenta* (profile-analysis, wetlands, fire). Ph.D. Dissertation. Duke University, Durham, NC. 186 pp.

A 20 to 40 year fire cycle controls nutrient availability in nutrient-deficient pocosins. Compensatory growth response to fire in plants resprouting from underground rhizomes may be due to destruction of aboveground parts, to fertilization, or both. Rather than being adapted to different nutrient regimes, the species studied (fetterbush lyonia and zenobia), despite differences in response to fertilization, are adapted to highly competitive conditions in which fire occasionally destroys aboveground parts, increases the liklihood of seedling establishment, and enhances the availability of the limiting nutrient, phosphorus. [From author's abstract]

224. Simms, E. L. 1985. Growth response to clipping and nutrient addition in *Lyonia lucida* and *Zenobia pulverulenta*. Am. Midl. Nat. 114:44–50.

Fertilization and clipping experiments simulating the effects of burning pocosin vegetation in North Carolina showed that nutrient addition increased growth of fetterbush lyonia and zenobia and that clipping had no effect on aboveground production per stem in either species. Destruction of aboveground parts by fire would therefore not be expected to reduce absolute rates of growth, but fire-caused nutrient enrichment could. [K–L–S]

225. Singleton, J. R. 1951. Production and utilization of waterfowl food plants on the east Texas Gulf coast. J. Wildl. Manage. 15:46–56.

Thirteen species of waterfowl food plants were examined in the Texas Gulf coast to determine environmental factors affecting their production. These factors included water level stability, plant competition, and time of burning. Burning in February had no effect on spring growth and subsequent plant blooming and seed production of saltmarsh bulrush or smartweed. Periodic burning of sawgrass thinned stands and made the seed available to waterfowl. Burning of marsh vegetation in this area should be delayed in the fall until waterfowl food plants such as barnyardgrass, smartweed, and seashore saltgrass have mature seed and these seeds have fallen. Late winter burning retarded the growth of sawgrass and accelerated spring growth of smartweed. [From author's abstract]

226. Singleton, J. R. 1965. Waterfowl habitat management in Texas. Tex. Parks Wildl. Dep. Bull. 47. 68 pp.

The author emphasizes waterfowl food plant identification and propagation, and the control of noxious plants. Although agricultural uses provide the greatest dollar return, lands that cannot be economically cultivated can nevertheless provide a return when managed for waterfowl and fisheries. The development and management of wintering waterfowl habitat can be attained through water control, controlled and regulated burning (where applicable), and controlled grazing. Low value grasses can best be controlled by burning, grazing, or plowing; fall burning of cordgrass and seashore saltgrass marshes increases food production for geese. Other species are controlled with more difficulty. The marsh should be divided into four approximately equal units and burned consecutively as follows: the first about 5 to 10 days prior to the opening of waterfowl hunting, and the second through fourth at successive 15-day intervals. Burned areas should be inundated with several inches of water to encourage growth. Marshes can be

managed to benefit both muskrats and waterfowl if controlled burning is employed. [K–L–S]

227. Sipple, W. S. 1978. A review of the biology, ecology, and management of *Scirpus olneyi*. Volume I: an annotated bibliography of selected references. Md. Dep. Nat. Resour. Wetland Publ. 2. 96 + [6] pp.

This is the first of a two-volume report compiled to assist a task force in its efforts to explain the substantial reduction in marsh acreage at Blackwater National Wildlife Refuge, Dorchester County, Maryland. The 180 references in this volume are discussed in greater detail in Vol. II. (Sipple 1979, q.v.). Twenty-seven of the included references mention fire or fire effects. [K–L–S]

228. Sipple, W. S. 1979. A review of the biology, ecology, and management of *Scirpus olneyi*. Volume II: a synthesis of selected references. Md. Dep. Nat. Resour. Wetland Publ. 4. 85 pp.

This paper synthesizes the material in Volume I (Sipple 1978, q.v.) to provide a thorough review of the ecology of Olney bulrush with emphasis upon the marsh loss problems of Blackwater National Wildlife Refuge. Olney bulrush growth is accelerated with the removal of marshhay cordgrass by fire; little bulrush will be found on sites never burned or grazed because of the superior competitive abilities of cordgrass. Marsh management on the Gulf and Atlantic coasts encourages Olney bulrush through controlled burning as one means to increase waterfowl and muskrat foods. Many references include discussion of the necessity of burning marshes every 1 or 2 years to maintain bulrush as a dominant species, but there are conflicting opinions on season to burn. Notwithstanding, burning at low water levels followed immediately by reflooding appears to be the best way to change vegetation type in favor of Olney bulrush. [K–L–S]

229. Slaughter, C. W., R. J. Barney, and G. M. Hansen, editors 1971. Fire in the northern environment—a symposium. U.S. For. Serv., Pac. Northwest For. Range Exp. Stn., Portland, OR. 275 pp.

This symposium explored aspects of wildfire in the subarctic. Major topics were the relationship of fire to the natural environment and man's use of the environment, as well as aspects of fire control in the region. Twenty-two presentations, a panel discussion, and symposium summary are provided. Papers from the symposium by Sykes (1971) and Lotspeich and Mueller (1971) are included in this bibliography. [K–L–S]

230. Smith, A. G. 1969. Waterfowl–habitat relationships on the Lousana, Alberta, waterfowl study area. Pages 116–122 *in* Saskatoon wetlands seminar. Can. Wildl. Serv. Rep. Ser. 6.

A review of the subject is presented based upon Alberta studies. The section on fire treats the phenomenon as a negative value for prairie ponds. Drought at Lousana followed by cultivation or burning did not prevent return of former species of aquatic plants, even though two successive crops of grain were harvested on the pond bed. Nonetheless, anything tending to increase evaporation, lower water levels, or in any way reduce the permanency of a pond adversely influenced the habitat features necessary to perpetuate an aquatic community. Emergent plants, especially cattails, unlike true aquatics, can be destroyed quickly by burning or cultivation. Increased use of a pond by livestock following burning of peripheral trees and shrubs hastens the process of pond destruction through trampling of vegetation and physical destruction of the pond basin. [K–L–S]

231. Smith, A. L. 1971. An autoecological study of the marsh grass, *Scolochloa festucacea* (Willd.) Link. Ph.D. Dissertation. Texas A&M University, College Station. 124 pp.

[The results of sampling 243 stands in North Dakota are presented. See Smith (1973*a*, 1973*b*) for details related to fire.]

232. Smith, A. L. 1973*a*. Life cycle of the marshgrass *Scolochloa festucacea*. Can. J. Bot. 51:1661–1668.

Whitetop rivergrass is an emergent, hydrophytic, monotypic grass with greatest abundance in North Dakota, Manitoba, and Saskatchewan. Pure stands form where litter

is removed by burning or mowing. It is replaced by awned sedge where undisturbed. Results of study of stands in 93 potholes are presented. [K–L–S]

233. Smith, A. L. 1973*b*. Production and nutrient status of whitetop. J. Range Manage. 26:117–120.

Whitetop rivergrass, an emergent hydrophytic grass of the north central U.S. and south central Canada, is a forage species that can be hayed if water levels drop sufficiently. Burning and mowing increased yield; grazing resulted in herbage equal to protected stands. Continuous grazing, however, will eliminate whitetop. (Production averaged 11,500 kg/ha in burned stands and 10,090 kg/ha on mowed stands while undisturbed stands produced only an average of 7,480 kg/ha.) Whitetop is an excellent forage producer following burning and mowing. Inundation of monodominant stands through flowering, followed by drainage prior to mowing, provides maximum production. [K–L–S]

234. Smith, E. R. 1960. Evaluation of a leveed Louisiana marsh. Trans. N. Am. Wildl. Nat. Resour. Conf. 35:265–275.

A fresh marsh covered by a stand of giant southern-wild rice was treated with stabilized water levels (+5 to –5 cm), cattle walkways, controlled grazing, and spraying of pest plants. After 5 years, the following was noted: no significant change in soils; a decrease in the basal density of marshhay cordgrass, common reed, and gulf cordgrass, and an increase in density of barnyardgrass, sprangletop, seashore paspalum, knotgrass paspalum, and other species; an overall increase in the amount of food available to wildlife; an increase in waterfowl and muskrat populations; a freshening of the marsh; an increase in the value for livestock; and a decrease in value for estuarine organisms. Burning one-third of the marsh per year retarded succession, released nutrients, removed rough, and hastened germination. [K–L–S]

235. Smith, L. M. 1983. Effects of prescribed burning on the ecology of a Utah marsh. Ph.D. Dissertation. Utah State University, Logan. 174 pp.

[See Smith et al. 1984 and Smith and Kadlec 1985*a*, 1985*b*, 1985*c*, 1985*d*, 1986]

236. Smith, L. M., and J. A. Kadlec. 1985*a*. Comparisons of prescribed burning and cutting of Utah marsh plants. Great Basin Nat. 45:462–466.

Cutting reduced production of hardstem bulrush, alkali bulrush, and common cattail compared to levels found on burned plots, but differences were significant ($P<0.05$) only within the alkali bulrush type. Clipping saltgrass plots greatly reduced production upon reflooding, producing results similar to prescribed burning and reflooding. Heat penetration into the sediments during fire was not sufficient to cause belowground mortality. Lacking belowground mortality, prescribed burning alone did not change aboveground production or species composition. Flooding after fire eliminated seashore saltgrass, but a single prescribed burning or cutting was not effective in reducing production of common cattail, hardstem bulrush, or alkali bulrush. [From authors' abstract]

237. Smith, L. M., and J. A. Kadlec. 1985*b*. Fire and herbivory in a Great Lake salt marsh. Ecology 66:259–265.

Standing crops and aboveground net primary production in common cattail, hardstem bulrush, alkali bulrush, and seashore saltgrass did not differ between burned and unburned areas, but saltgrass was virtually eliminated by burning and reflooding. Flooding without burning did not harm seashore saltgrass. Waterfowl and muskrats significantly reduced production and standing crops of the bulrushes and common cattail. Evidence of increased protein in vegetation following fire and observed preferential grazing of the more nutrient-rich above ground tissue was consistent with the hypothesis that wetland vertebrates select higher quality foods. However, other factors, including increased foraging efficiency in burned plots, may have also been in effect. [From authors' abstract]

238. Smith, L. M., and J. A. Kadlec. 1985*c*. Predictions of vegetation change following fire in a Great Lake salt marsh. Aquatic Bot. 21:43–51.

Seedbank samples from five vegetation types (seashore saltgrass, hardstem bulrush, alkali bulrush, common cattail, and open water) were used in conjunction with plant life history characteristics to predict post-fire species composition for each vegetation type and for the entire study area. In general, predictions for specific vegetation types were not good, but greater accuracy was obtained for the entire area. Reasons for lack of predictive ability of the Gleasonian model of succession are presented; the value of using seed banks to predict postmanipulation changes in marsh is emphasized. [From authors' abstract]

239. Smith, L. M., and J. A. Kadlec. 1985*d*. The effect of disturbance on marsh seed banks. Can. J. Bot. 63:2133–2137.

Seed numbers and species composition of seed banks (germinable seeds) from a marsh adjacent to Great Salt Lake were compared among five vegetation types prior to a drawdown, after a drawdown, and prior to fire, after fire, and after restoration of normal water levels. Numbers of germinable seeds were not depleted by drawdown, possibly owing to increased salinity and the presence of standing vegetation. Fire had little effect on seed banks. In general, seed banks were not affected by drawdown or burning. Movement of seeds into different vegetation types could be important in potential vegetation change. Seeds moved across open water sites until a barrier (e.g., vegetation) was reached. [From authors' abstract]

240. Smith, L. M., and J. A. Kadlec. 1986. Habitat management for wildlife in marshes of Great Salt Lake. Trans. N. Am. Wildl. Nat. Resour. Conf. 51:222–231.

Prior to modern development of Great Salt Lake marshes, marsh vegetation was confined to deltas of freshwater rivers. The value of these marshes prompted early management by spreading freshwater over salt flats to favor aquatic macrophytes. Stable water levels resulted in unfavorable habitat change (monospecific common reed and cattail) and a decline in waterfowl production. Habitat related research during the 1960's and 1970's resulted in an emphasis upon disturbances as a management tool. Burning, cutting, flooding, and salinity manipulation are proper management techniques for selected habitat manipulation goals. In general, periodic disturbance is natural and essential for long-term productivity (in terms of wildlife populations) of marshes. A knowledge of plant life history strategies is necessary to predict the result of disturbance sequences. When the current extraordinarily high lake levels recede and new dikes are constructed, plant succession will be determined by environmental factors such as sediment salinity, survival of seeds and underground plant structures, and dispersal of propagules within the marshes. [From authors' abstract]

241. Smith, L. M., J. A. Kadlec, and P. V. Fonnesbeck. 1984. Effects of prescribed burning on nutritive quality of marsh plants in Utah. J. Wildl. Manage. 48:285–288.

The hypothesis that prescribed burning may improve the nutritive quality of marsh plants was tested in a study of a Utah marsh. Fall burning increased protein in seashore saltgrass, tule bulrush, and cattail, but not in alkali bulrush. Further studies are needed to determine whether wetland vertebrates will respond to higher nutritive quality vegetation with increased grazing intensity and/or increased reproductive performance. [K–L–S]

242. Smith, R. H. 1942. Management of salt marshes on the Atlantic coast of the United States. Trans. N. Am. Wildl. Conf. 7:272–277.

The management techniques used on an area depend largely on production objectives. Marsh management includes physical improvements or development, and cultural practices. These techniques involve creation of water areas, alteration of salinity levels, damming and diking, burning, harvest of marsh grasses, and direct planting and seeding. Marsh fires can be classified as cover, root, or peat burns. Cover burns are light and are usually carried out between 15 October and 1 March. They remove vegetative debris, thereby making food available to waterfowl, encouraging growth of high-grade muskrat and waterfowl food plants, providing succulent grazing for geese in saltmarsh bulrush/American bulrush meadows and cattail marshes, and making dense marsh areas accessible to muskrat trappers. Root

burns are hotter and are designed to alter vegetative composition through control and replacement of various low-value marsh species. They must be undertaken when the marsh floor is dry to be effective, necessitating care to prevent damage to wildlife. Peat fires burn holes in the marsh floor to provide additional water areas. [K–L–S]

243. Soileau, D. M. 1968. Vegetative reinvasion of experimentally treated plots in a brackish marsh. M.S. Thesis. Louisiana State University, Baton Rouge. 74 pp.

Burning, tilling, chemical treatment, and combinations of the three were applied to brackish marsh in Rockefeller Refuge, LA. Burning and tilling reduced the growth of undesirable marshhay cordgrass and seashore saltgrass. Burning plus tilling was more effective than either alone and allowed saltmarsh bulrush to re-invade the plots. Chemicals increased the kill of undesirables when combined with other treatments. Best growth occurred in all species from May through October with a general decline from November through April. [From author's abstract]

244. Staub, J. R., and A. D. Cohen. 1979. The Snuggedy Swamp of South Carolina: a back-barrier estuarine coal-forming environment. J. Sediment. Petrol. 49:133–144.

Two types of splays are recognized in the estuarine peat. Crevasse splays are of small areal extent and are composed of clay and silt. Fire splays are of large areal extent and are caused by burned out portions of the peat in the swamp forming depressions which flood with sediment-laden water. Gradational sediments form in these depressions with fusinite (charcoal) at the base, grading upward into clayey peat and then into peaty clay. In coal seams, the crevasse splays would be compressed and consolidated into shale splits of small lateral extent. Fire splays, in contrast, would form bone and carbonaceous shale splits of great lateral extent, and the charcoal zone at their base could possibly be used as a relative time line to correlate individual coal seams. [From authors' abstract]

245. Stevenson, J. C., and L. G. Ward. 1985. Vertical accretion in marshes with varying rates of sea level rise. Estuaries 8(2B):71A. (Abstract only)

An apparent reversal in trends of marsh accretion in many areas (about 25% of reported sedimentation rates are less than sea level rise) was reviewed in terms of models of marsh accretion patterns. Man-related activities of burning, ditching, and tidal exclusion, all of which affect marsh accretion, were included. [From authors' abstract]

246. Stevenson, J. O., and L. H. Meitzen. 1946. Behavior and food habits of Sennett's white-tailed hawk in Texas. Wilson Bull. 58:198–205. The ecological relations of white-tailed hawks were studied at Aransas National Wildlife Refuge and the Texas coast north to Houston and Galveston Bay. These raptors invariably congregated at prairie fires in search of food. At a burn of a 60-ha tract of gulf cordgrass, 36 raptors of 6 species, including 20 white-tailed hawks, hunted along the edge of the fire line for hispid cotton rats, pocket mice, and grasshoppers. [K–L–S]

247. Steward, K. K., and W. H. Ornes. 1975. The autoecology of sawgrass in the Florida Everglades. Ecology 56:162–171.

Mature sawgrass stands showed little seasonal variation in standing crop, plant density, or concentration of most inorganic nutrients. Plant nutrient requirement estimates were low; most nutrients were in adequate supply except that available N, P, K, and Cu were generally very low. Concentration of most nutrients in culms regrowing after fires was high during early growth stages, but decreased to levels found in older culms after 3–5 months (Ca, Fe, and Zn were the exceptions). After 18 months of growth, burned stands had produced only 38% of the standing crop contained in unburned mature stands. Apparent low nutrient demands by sawgrass may partially explain its dominance. [From authors' abstract]

248. Stoudt, J. H. 1982. Habitat use and productivity of canvasbacks in southwestern Manitoba, 1961–72. U.S. Fish Wildl. Serv., Spec. Sci. Rep.—Wildl. 248. 31 pp.

A decrease in breeding canvasback pairs in

1967 may have been caused by a decrease in nesting cover brought about by extensive burning of cattail and bulrush in fall 1966. [K–L–S]

249. Swanston, D. N. 1980. Influence of forest and rangeland management on anadromous fish habitat in western North America: impacts of natural events. U.S. For. Serv. Gen. Tech. Rep. PNW–104. 27 pp.

The immediate impact of fire is to increase both water yield and stormflow discharge from a watershed. Surface runoff from burned areas generally increases dissolved nutrient transport and loading of the channel systems. Large volumes of debris and sediment can be transported. From 1 to 5 years afterward, fire may increase potential for accelerated landslide activity through decay of root systems. In steep terrain, loosened debris can choke streams. Hydrophobic soils often form after fires, dramatically changing watershed characteristics. Fire affects nutrient availability and subsequent nutrient loading of streams. Chemical effects are generally not harmful to fish. Physical effects (debris torrents, sediment flushing, landslides) are far more harmful. [K–L–S]

250. Sykes, D. J. 1971. Effects of fire and fire control on soil and water relations in northern forests—a preliminary review. Pages 37–44 *in* C. W. Slaughter, R. J. Barney, and G. M. Hansen, eds. Fire in the northern environment—a symposium. U.S. For. Serv., Pac. Northwest For. Range Exp. Stn., Portland, OR.

In the scattered existing data, there is disagreement regarding effects of fire on soil temperatures, permafrost degradation, destruction of the organic mat, soil erosion, and other factors, but this is expected considering the wide variation in soils, geology, climate, and vegetation of the subarctic. Some observers indicate more serious damage from past fire suppression methods than from the fires themselves. A brief, preliminary review of work pertaining to effects of fire in northern forests is presented. [From author's abstract]

251. Taylor, D. L., and R. R. Gibbons. 1985. Use of fire plows in a marsh. Fire Manage. Notes 46(3):3–6.

Plow lines in Big Cypress National Preserve change elevation to encompass the range of most plant communities, possibly disrupt mycorrhizal associations, and impact water flows. Existing off-road vehicle trails are suggested as an alternative to plow lines for fire suppression. [From authors' abstract]

252. Tester, J. R., and W. H. Marshall. 1962. Minnesota prairie management techniques and their wildlife implications. N. Am. Wildl. Nat. Resour. Conf. 27:267–287.

Suggested management for the Waubun Prairie, MN, and similar areas is a 4-year rotation of spring burn, no treatment, graze, and no treatment. Burning does not seem to greatly alter the marsh edge community as does grazing, but does remove thick debris. Removal of all cover in upland areas adjacent to wetlands by burning would locally reduce waterfowl nesting opportunities. [K–L–S]

253. Tewes, M. E. 1982. Response of selected vertebrate populations to burning of gulf cordgrass. M.S. Thesis. Texas A&M University, College Station. 131 pp.

Study sites were established at the Rob and Bessie Welder Wildlife Refuge and Aransas National Wildlife Refuge, TX, to monitor responses of various wildlife populations to the prescribed burning of gulf cordgrass. The research design utilized a holistic, community approach with focus on the small mammals, birds, and medium-sized mammals. Rodent densities and biomass, particularly those of hispid cotton rats, were drastically reduced by burning. Numbers remained low on the treated site until grazing ceased and vegetative cover reappeared in late spring. Higher rodent populations appeared the following fall. Populations of some bird species, notably the savannah sparrow, Le Conte's sparrow, eastern meadowlark, and sedge wren, were reduced following the burn. Other species, such as the long-billed curlew, common snipe, mourning dove, and killdeer, were attracted to the open postburn habitat and fed on exposed prey. An ecotonal influence was detected with higher bird density and diversity present at the burned-unburned cordgrass juncture than on the interior of the postburn. [From author's abstract]

254. Tewes, M. E. 1984. Opportunistic feeding by white-tailed hawks at prescribed burns. Wilson Bull. 96:135–136.

Congregations of white-tailed hawks and other raptors at upland and wetland prescribed burns on Welder Wildlife Foundation and Aransas National Wildlife Refuge, TX., were documented. Although hawks may feed on rodents and other prey during and immediately following a burn, extensive burns remove cover and reduce prey population until the vegetation recovers. [K–L–S]

255. Thompson, D. J. 1982. Effects of fire on *Phragmites australis* (Cav.) Trin. ex Steudel and associated species at the Delta Marsh. M.S. Thesis. University of Manitoba, Winnipeg. 199 pp.

[See Thompson and Shay 1985]

256. Thompson, D. J., and J. M. Shay. 1985. The effects of fire on *Phragmites australis* in the Delta Marsh, Manitoba. Can. J. Bot. 63:1864–1869.

Common reed shoot biomass was greater after spring and fall burns in comparison with controls but less on summer-burned plots. Total shoot density was higher after all burning treatments. Flowering shoot density was lower after summer and fall burns but higher following spring burns. All burn treatments resulted in lower mean shoot weight. Belowground standing crop was higher by mid-September on spring- and fall-burned plots but not on those burned in the summer. The seasonal minimum total nonstructural carbohydrate contents of the rhizomes were reduced after summer and spring burns in comparison with controls. Optimal time to burn to increase reed performance may be mid-May. Time for a burned stand to return to preburn performance is not known, but would provide a guide to the optimum burn interval. [From authors' abstract]

257. Thompson, D. Q. 1959. Biological investigation of the Upper Fox River. Wis. Conserv. Dep. Spec. Wildl. Rep. 2. 41 pp.

This report was a biological survey of the Upper Fox River made in anticipation of transfer of management responsibility from the Corps of Engineers to the State government. Review of data from the original Northwest Survey showed that the Fox River Marshes had changed little since the mid-1800's. Recurrent fire was identified as the agent destroying woody seedlings and maintaining the sedge-grass community. Changed land use in the uplands of the watershed now provide less opportunity for wildfire. The result is invasion by willow except in those areas where accidental or intentional fire has retarded succession. [K–L–S]

258. Tiedemann, A. R., C. E. Conrad, J. H. Dieterich, J. W. Hornbeck, W. F. Megahan, L. A. Viereck, and D. D. Wade. 1979. Effects of fire on water: a state-of-knowledge review. U.S. For. Serv. Gen. Tech. Rep. WO-10. 28 pp.

Studies of wildfire and prescribed burning are used to assess fire effects on water. Where possible, the effects of wildfire suppression activities, such as mechanical fireline construction and aerial application of retardant chemicals, are also addressed. Post-wildfire and post-prescribed burn activities, such as erosion control and fertilization, are also addressed. Onsite effects, downstream effects (including water quality), and changes in aquatic habitat are discussed in detail; 137 citations are listed. [K–L–S]

259. Tilmant, J. T. 1975. Habitat utilization by round–tailed muskrats (*Neofiber alleni*) in Everglades National Park. M.S. Thesis. Humboldt State University, Arcata, CA. 91 pp.

Prescribed burns conducted when water levels are above the soil surface can reduce muskrat numbers or destroy entire colonies. Burns conducted when water levels are at or below the soil surface result in the least damage because the animals can burrow for protection if soils are deep. Burns in late dry season can also be detrimental if early rains cause sudden flooding of burrows. [K–L–S]

260. Train, E., and F. P. Day, Jr. 1982. Population age structures of tree species in four plant communities in the Great Dismal Swamp, Virginia. Castanea 47:1–16.

The age structure of four different plant

communities [Atlantic white-cedar, baldcypress, red maple/water tupelo, and mixed hardwood (swamp tupelo/oak)] was determined from increment bores. Red maple was an expanding population in the maple-tupelo, cypress, and cedar stands, and baldcypress and Atlantic white-cedar were declining in the cypress and cedar stands, respectively. Cypress is in decline and being replaced by hardwoods able to germinate beneath the closed canopy. Red maple is expanding in cedar stands because of lack of fire or mechanical scarification which would permit cedar seed germination. [From authors' abstract]

261. Trippensee, R. E. 1953. Wildlife management. Vol. 2. Fur bearers, waterfowl and fish. McGraw Hill Book Co., New York. 572 pp.

Fire is mentioned briefly in the chapter that addresses marsh and swamp management in this general text. Surface burns, done when underlying solid matter is saturated, can provide waterfowl habitat and fire protection by removing "rough" debris, encourage lush new vegetation for wildlife food, and facilitate movements of wildlife and people in a marsh. Root burns kill climax vegetation and can cause deep pits to form in the marsh floor, thus providing open water for waterfowl and fur bearers. After a marsh drys to a depth of 15 cm (6 inches), giant southern-wild rice, common reeds, sawgrass, cattails, mints, and river bulrush can be burned for control purposes. Fires should be set when birds are not nesting and plants are dormant. [K–L–S]

262. Truax, W. C., and L. F. Gunther. 1951. The effectiveness of game management techniques employed on Horicon Marsh. Trans. N. Am. Wildl. Conf. 16:326–330.

Management of semi-aquatic habitat on the Horicon National Wildlife Refuge, Wisconsin, consists, in part, of controlled burning of from 3,238 to 4,047 ha (8,000 to 10,000 acres) in late fall or winter to: (1) create spring pasture for geese; (2) retard litter accumulation on the marsh floor; (3) control undesirable woody plants; (4) burn out peat holes; and (5) prevent incendiary fires. [K–L–S]

263. Turner, M. M. G. 1985*a*. Ecological effects of multiple perturbations on a Georgia salt marsh. Ph.D. Dissertation. University of Georgia, Athens. 192 pp.

Clipping and trampling each reduced peak biomass by similar amounts, 20% in 1983 and 50%–55% in 1984; burning reduced peak biomass by 35% in 1984. Trampling and burning each reduced net aboveground primary productivity (NAPP) by about 35%; clipping did not reduce NAPP when known losses to clipping were accounted for. Perturbations reduced belowground standing stocks of live rhizomes which were correlated with aboveground biomass ($r=0.43$; $p<0.001$). Clipping and trampling, when combined, exhibited a proportional relationship. Combinations of perturbations which included burning had less than additive effects. Horses had a strong impact on the high marsh, reducing standing stocks of live smooth cordgrass from 360 g to 40 g dry weight per square meter, and reducing NAPP by up to 50%. A simulation model suggested there is a threshold of tolerance for grazing in the marsh. [From author's abstract]

264. Turner, M. M. G. 1985*b*. Effects of feral horse grazing, clipping, trampling and a late winter burn on a salt marsh, Cumberland Island National Seashore, Georgia. Bull. Ecol. Soc. Am. 66:285. [Abstract only]

Net aboveground productivity (NAPP) of replicate 200 m^2 smooth cordgrass plots was reduced by all combinations of grazing, trampling, and clipping. NAPP of burned, burned and trampled, and burned and grazed plots was about 70% of unburned equivalents; NAPP of burn + clip and burn + clip + trample plots was similar to unburned equivalents. Burning did not reduce rhizome productivity; grazing, clipping, and trampling had the opposite effect. Total belowground organic matter did not change in the 17-month study, but invertebrate abundance was decreased by clipping and trampling. [From author's abstract]

265. Turner, M. M. G. 1987. Effects of grazing by feral horses, clipping, trampling, and burning on a Georgia salt marsh. Estuaries 10:54–60.

[See Turner 1985*a*, 1985*b*]

266. Uhler, F. M. 1944. Control of undesirable plants in waterfowl habitats. Trans. N. Am. Wildl. Conf. 9:295–303.

Fire is considered to be "the best single tool available" for controlling undesirable marsh plants. It is inexpensive, easy to use, and highly effective, although it must be handled with care and should not be used during the avian breeding season. Three types of burns are recognized. Surface burns, which are made when water is shallow, temporarily release valuable plants that have an earlier growing season than objectionable species and make available as food tender new growth. Cattail and cordgrass can be controlled and seed production of sawgrass stimulated by such burns. Root burns, made when marsh soil has dried to a depth of 8 to 15 cm, control species such as giant southern-wild rice, common reed, sawgrass, cattail, mints, river bulrush, and other unproductive sedges. Peat burns, made only during droughts and when the goal is to convert a marsh into a truly aquatic environment, remove the substrate sufficiently to develop open water. Solid stands of reed, cattail, and sedges have been converted into productive nesting grounds by localized use of these burns. [K–L–S]

267. U.S. Fish and Wildlife Service. 1964*a*. Supporting Papers I/C. 1. Managing wetlands for wildlife. Pages 219–231 *in* L. Hoffman, compiler. Project MAR. The conservation and managment of temperate marshes, bogs and other wetlands. Vol. 1. Proc. MAR Conf. organized by IUCN, ICBP, and IWRB at Les Saintes-Maries-de-la-Mer, 12–16 November 1962. IUCN Publ. (New Ser.) 3.

The principal wetland management techniques are classified as mechanical, chemical, biological, and cultural. Controlled burning is considered a cultural technique of proven value. Superficial burns over saturated soils remove current growth and accumulated litter. Total elimination of perennial vegetation is possible during deep burns when the marsh is dry. Deep burns increase the depth of the marsh, setting back succession to submergent stages. Cultivation is sometimes necessary if ash deposits are deep. Burning combined with cultivation and planting of agricultural crops or fallowing has been effective in eliminating excessive growths of cattails, burreed, and various bulrushes which may survive either burning or deferral of reflooding for a year or two. [K–L–S]

268. U.S. Fish and Wildlife Service. 1964*b*. Supporting Papers I/D. 1. Restoration of altered wetlands. Pages 336–346 *in* L. Hoffman, compiler. Project MAR. The conservation and managment of temperate marshes, bogs, and other wetlands. Vol. 1. Proc. MAR Conf. organized by IUCN, ICBP, and IWRB at Les Saintes-Maries-de-la-Mer, 12–16 November 1962. IUCN Publ. (New Ser.) 3.

Restoration of Bear River Marshes, Mattamuskeet Lake, and Okefenokee Swamp are discussed as examples of U.S. restoration of altered wetlands. Summer burning and cultivation in the marsh zone of Mattamuskeet discourages lesser value plants such as smooth cordgrass and cattails from invading stands of American bulrush, a high quality waterfowl food. Fire has been strictly controlled in Okefenokee Swamp since the combination of drought and fires is extremely destructive. No long-term effects of either fire or drought on the wildlife and fish of Okefenokee have been observed. It is now evident that although drought and accompanying fires may drastically change the appearance of the Swamp for a few years, they do not alter its biological character. [K–L–S]

269. U.S. Forest Service Library. 1938. Effects of fire on forests. A bibliography. USDA, Washington, DC. 130 pp.

Eighteen entries under the topic "Effects on soil," 19 entries under "Effects on recreation and wildlife," and 47 entries that mention or discuss in detail the effects of fire on watersheds illustrate the state of knowledge in 1938. Only one paper (Conway 1938) mentions fire and wetlands per se. The deleterious effects of erosion following fire were the major fire–water relations of interest in the years covered. [K–L–S]

270. Van Armann, J., and R. Goodrick. 1979. Effects of fire on a Kissimmee River marsh. Fla. Sci. 42:183–195.

A marsh composed primarily of maidencane

panicum and lance pickerelweed in the Kissimmee River floodplain was studied to determine the effects of fire on productivity. Recovery of a burned 100 m^2 plot occurred within 6 months. Total number of both animal species and individuals was significantly greater in the burned than in the control plot. Burning appears to be a useful management tool in this floodplain to increase secondary productivity when used in conjunction with manipulation of water levels. [From authors' abstract]

271. Van Lear, D. H. and V. J. Johnson. 1983. Effects of prescribed burning in the southern Appalachian and upper Piedmont forests: a review. Clemson University, Clemson, SC. Coll. For. Recr. Resour., Dep. For., For. Bull. 36. 8 pp.

Information on effects of prescribed burning in the Southern Appalachians and Upper Piedmont is reviewed. Although wetlands are not discussed as a habitat type, effects of prescribed fire on soil, vegetation, wildlife habitat, water, and air are discussed. Areas needing additional research are identified. [From authors' abstract].

272. Verme, L. J., and J. J. Ozoga. 1981. Changes in small mammal populations following clear-cutting in Upper Michigan conifer swamps. Can. Field-Nat. 95:253–256.

Strip clear-cutting in Upper Michigan increased the relative abundance of small mammals, especially deer mice, least chipmunks, and meadow voles. Compared to a clear-cut block with slash left unburned, broadcast burning of slash resulted in greater populations of shrews, mainly masked shrews, and deer mice. Because northern white-cedar reproduced adequately, small rodents were thought to have little effect upon conifer swamp regeneration in this locale. [From authors' abstract]

273. Vierick, L. A. 1973. Wildfire in the taiga of Alaska. Quat. Res. (NY) 3:465–495.

The boreal forest of northern Alaska is primarily open, slow-growing spruce interspersed with occasional dense forest stands and treeless bogs. This vegetation mosaic results primarily from past wildfires. A major important effect of fire on the taiga is its effect on permafrost and the soil nutrient cycle. Construction of fire lines often has had greater effect upon the environment than fire itself. Specific effects of fire upon the landscape, soil, flora, and fauna are discussed as well as fire's effects on recreation and aesthetic values. [K–L–S]

274. Vierick, L. A., and L. A. Schandelmeier. 1980. Effects of fire in Alaska and adjacent Canada—a literature review. U.S. Bur. Land Manage. Tech. Rep. 6 (BLM/AK/TR–80/06). 124 pp.

This review attempts to interpret all available literature (published and unpublished) on fire effects in the Far North, both in forested (taiga) and tundra regions. Literature from biogeographically similar regions, such as northern Minnesota, Michigan, etc., is also included. Approximately 750 references were reviewed; all major topics of fire effects on biological systems are covered. Summaries of the effects of fire on particular species are included where data warrant. The outline of available databases on fire and the search strategy used to develop this review provide an excellent guide to the fire effects literature, particularly important symposia and workshops, for all of North America up to 1980. [K–L–S]

275. Viosca, P., Jr. 1928. Louisiana wetlands and the value of their wildlife and fishery resources. Ecology 9:216–229.

Following a description of Louisiana's wetlands and its flora and fauna, man-made changes in the natural system are outlined. Canalization, since it dries the marsh, permits disastrous fires which burn holes to mineral soil through the humus layers. [K–L–S]

276. Viosca, P. J., Jr. 1931. Spontaneous combustion in the marshes of southern Louisiana. Ecology 12:439–442.

Spontaneous combustion of marsh peat was attributed to drying of the marsh in combination with temperatures above 100° F, strong winds, high humidity, and abundant sunlight. These conditions were hypothesized to be responsible for accelerating the normally

slow oxidation of the peat until ignition occurred. [K–L–S]

277. Vitt, D. H., and S. Bayley. 1984. The vegetation and water chemistry of four oligotrophic basin mires in northwestern Ontario. Can. J. Bot. 62:1485–1500.

Water chemistry from portions of a mire burned in 1974 showed no differences from unburned portions. Except for the presence of several seral plant species indicative of recent fire, no significant vegetation differences existed in 1981 and 1982. [K–L–S]

278. Vogl, R. J. 1964. The effects of fire on a muskeg in northern Wisconsin. J. Wildl. Manage. 28:317–329.

A prescribed burn produced a conversion or retrogression from conifer swamp dominated by trees to open sphagnum bog or muskeg dominated by sedges and ericaceous shrubs in north-central Wisconsin. The muskeg may be changed further to northern sedge meadows, dominated by sedges and supporting a minimum of woody vegetation. Such meadows are more desirable than other successional stages because they allow the greatest movement, feeding, and nesting of game birds. Fire also improved game habitat by reducing the "rough" of woody and nonwoody plants, stimulating new and palatable growth, and increasing fruit and seed production. [From author's abstract]

279. Vogl, R. J. 1967. Controlled burning for wildlife in Wisconsin. Proc. Annu. Tall Timbers Fire Ecol. Conf. 6:47–96.

In Wisconsin, fire historically maintained attractive duck breeding habitat by inhibiting plant succession. Grassy and herbaceous upland vegetation established and maintained by fires provides excellent cover for upland nesting ducks, such as blue-winged teal and mallard. In marshes with peat substrates, depressions are created by deep burns in dry years and afford open water when flooded. Fire is also used to clear flowage basins before diking and flooding. The ash promotes growth of desirable aquatic plants. Used in conjunction with water level drawdowns, fire can help create pioneer sites for establishment of waterfowl foods. Excessive accumulations of fast-growing hydrophytes are removed, permitting better waterfowl access and a more palatable regrowth. Burning of sedge meadows and wet marshy areas provides excellent grazing for geese, waterfowl, white-tailed deer, and nongame species such as sandhill cranes. Fire is also used to retard hydrarch succession and the advance of woody vegetation. [K–L–S]

280. Vogl, R. J. 1969. One hundred and thirty years of plant succession in a Wisconsin lowland. Ecology 50:248–255.

The postglacial history of a marl and peat marsh in Wisconsin contained evidence that early hydrarch succession may have been relatively rapid due to higher plant, as well as invertebrate animal, productivity. Pristine open marsh, sedge meadow, and wet prairie were held in quasi-equilibrium by alterations of floods during wet periods and fires during drought. Fires either checked terrestrial advancement or turned it back to earlier aquatic stages by organic substrate removal. Recent fire control and continued lowering of water levels hastened intermediate hydrarch succession by quickly and directly converting aquatic to terrestrial sites. A peat burn increased soil pH and soil nutrients, particularly the phosphates, and eliminated plant competition so that open marsh was immediately invaded by aspen forest, which if uninterrupted, will be converted to lowland hardwood forest. Recurring fires could perpetuate the sucker-sprouting aspen, but burning decadent aspen forest might originate true prairie. Although fire is usually catastrophic and retrogressive, it produced successional stability and even acted as a successional accelerator in this lowland. [From author's abstract]

281. Vogl, R. J. 1973. Effects of fire on the plants and animals of a Florida wetland. Am. Midl. Nat. 89:334–347.

Wildlife responses to fire were assessed in a wet prairie along the shore of a large north Florida pond. In the 4 months following the fire, more than three times more birds were observed on the burned area than an adjacent and comparable unburned shoreline. Only 5 of the 35 bird species encountered were seen more

often on the unburned site. Fire-induced bird and mammal injury or mortality was unobserved even though the burn resembled a wildfire. Birds showed no fear of the fire and some were attracted to the smoking landscape. Although some cold-blooded vertebrate mortality occurred, other reptiles and amphibians survived, and American alligators used the burned shoreline almost exclusively. Four months after the fire, mammal populations of burned and unburned areas appeared similar. Animal population responses were considered related to the fire removal of the heavy grass mat that otherwise covered the water and soils and the foods contained therein, and physically impaired new plant growth. Burning also produced an earlier, more rapid, and far more productive growth of wet-prairie plants. [From author's abstract]

282. Wade, D., J. Ewel, and R. Hofstetter. 1980. Fire in south Florida ecosystems. U.S. For. Serv. Gen. Tech. Rep. SE-17. 125 pp.

This is a compendium of fire information on selected south Florida vegetative communities, including a summary of fire history and an assessment of damages and benefits. Fire's relationship to certain exotic species is also addressed. The major vegetative types considered are sawgrass marsh; wet prairie and slough; freshwater marsh and marsh prairies; saltmarsh; mangroves; mixed hardwood swamps; cypress (stands, domes, and dwarf forests); tree islands (bayheads and hammocks); pine flatwoods; and Miami Rock Ridge pinelands. The historical effects of fire on evolving south Florida ecosystems and the responses of each vegetative type to changes in frequency and intensity of fire are described. [K–L–S]

283. Walker, J. L. 1985. Species diversity and production in pine–wiregrass savannas of the Green Swamp, North Carolina. Ph.D. Dissertation. University of North Carolina at Chapel Hill. 260 pp.

Variation in species richness with fire frequency is consistent with nonequilibrium theories of species diversity, and phenological differences in aboveground growth suggest that temporal resource partitioning acts as an equilibrium mechanism for maintaining diversity in these savannas. Most grasses rely upon a physiologically conservative stress tolerant strategy while the sedges and bluestem exhibit more competitive ruderal characteristics. [From author's abstract]

284. Walker, J., and R. K. Peet. 1983. Composition and species diversity of pine–wiregrass savannas of the Green Swamp, North Carolina. Vegetatio 55:163–179.

Both equilibrium (phenological variation in production among similar species and changes in species composition across the moisture gradient) and nonequilibrium (fire) processes appear to contribute to the establishment and maintenance of high species diversity in the Green Swamp savannas (grass-sedge bogs). Species richness in dry, mesic, and wet savannas varied with fire frequency, but effects were less pronounced at the extremes of the moisture gradient. Fire reduces woody plants and thus maintains the savannas, removes grass and sedge foliage which otherwise casts shade and leads to loss of smaller grasses and forbs, stimulates flower and seed production, and opens microsites where seedlings may become established. Data on species composition, richness, diversity, production, and response to fertilization are provided. [From authors' abstract]

285. Ward, E. 1942. Phragmites management. Trans. N. Am. Wildl. Conf. 7:294–298.

Spring burning removes stands of dead canes, but does not burn roots, so only temporary change is effected. Late summer burning kills roots, thus yielding more permanent changes. Spring burning is effective in opening dense, unbroken beds of phragmites to increase the nesting "edge" for waterfowl, which nest in the old growth from the previous year. Openings created by spring burning do not fill with new growth until early summer in southern Manitoba (Delta Marsh). Late summer burns create deep holes in the peat, developing depressions which fill with runoff in the subsequent spring. Spring burning should take place between first thaws and the beginning of the mallard and northern pintail breeding season in mid-April. Late summer burns may be conducted any time that conditions are favorable. Spring burns are easily controlled

because the wet soil and snow around the roots confine the burn to the surface. Deep peat fires which may be started by late summer burns are difficult to control without using heavy machinery to cut firebreaks in the peat. [K–L–S]

286. Ward, P. 1968. Fire in relation to waterfowl habitat of the Delta Marshes. Proc. Annu. Tall Timbers Fire Ecol. Conf. 8:255–268.

Controlled burning as a practical management technique for manipulating cover on the Delta Marsh in south-central Manitoba is discussed. Recurring fires perform a vital role in removing dense stands of dead and decaying vegetation and in maintaining the climax status of common reed. Spring fires remove vegetation but do not affect regrowth. Summer fires, however, can have lasting effects on regrowth. The author discusses the aspects of marsh burning most unfavorable to wildlife: destruction of nesting habitat during the waterfowl breeding season (forcing birds to concentrate in unburned cover and making them more vulnerable to predation) and loss of the marsh's ability to catch and retain drifting snow. This latter effect can be vital to marsh survival in areas of low annual precipitation. Conditions for ideal burning and for fire control are discussed. [K–L–S]

287. Wein, R. W. 1976. Frequency and characteristics of arctic tundra fires. Arctic 29:213–222.

Arctic tundra fires occur, but there are few actual records of them. Most fires for which data were available were less than 1 km^2, but three tundra fires on the Seward Peninsula of Alaska burned, in aggregate, 16,000 km^2 of cottonsedge tussocks. Tundra fires can appear as early as May, but most break out in July and August. Farther north, biomass decreases, and fires are more easily stopped by discontinuities in vegetation, wet areas, or physical obstructions. Although most fires are lightning-caused, man has initiated some. These man-caused fires will increase with greater use of the tundra. Little is known of the ecological significance of these fires, and only generalities on fire behavior can be stated with certainty. [From author's abstract]

288. Wein, R. W. 1983. Fire behavior and ecological effects in organic terrain. Pages 81–96 *in* R. W. Wein and D. A. MacLean, eds. The role of fire in northern circumpolar ecosystems. Scientific Committee on Problems of the Environment (SCOPE) 18. John Wiley & Sons Ltd., Chichester, England.

Almost all terrestrial ecosystems in the boreal circumpolar north accumulate organic matter, with greater accumulation at higher soil moisture levels. Fire frequencies in organic terrain are comparatively low, but during drought conditions, even organic terrain will burn. Both flaming and glowing combustion are common when organic soil is dry. Glowing combustion may burn in deep organic deposits for weeks, months, or even seasons in the remote north. This chapter reviews the literature and synthesizes a picture of fire behavior as a basis for understanding some of the ecological effects of organic terrain fires. [From author's abstract]

289. Wein, R. W., M. P. Burzynski, B. A. Sreenivasa, and K. Tolonen. 1987. Bog profile evidence of fire and vegetation dynamics since 3000 years BP in the Acadian forest. Can. J. Bot. 65:1180–1186.

Charred particles and pollen preserved in bogs near Marcelville and Fredericton, New Brunswick, indicated a constant rain of distant-source small particles. Studies of charcoal transport during prescribed burns identified the diameters of charcoal particles useful in determining local fires. The greatest Province-wide fires and changes in forest composition occurred at about 2200, 1750, 1550, and 400 years BP. Temporal patterns of charcoal deposit were similar in the two bogs and supported data from Nova Scotia and Maine. Fires seem to have acompanied the establishment of present forest types around 1450 BP. [From authors' abstract]

290. Wein, R. W., and D. A. MacLean. 1983*a*. An overview of fire in northern ecosystems. Pages 1–18 *in* R. W. Wein and D. A. MacLean, eds. The role of fire in northern circumpolar ecosystems. Scientific Committee on Problems of the Environment (SCOPE 18). John Wiley & Sons Ltd., Chichester, England.

This introductory chapter reviews the spatial and temporal diversity of fire in northern circumpolar ecosystems. Long day length in summer, presence of permafrost, low biological productivity, and other factors cause the role of fire in the North to differ from that in more temperate systems. Contrasts with temperate and tropical fire effects are stressed, and use of fire as a management tool is discussed. [From authors' abstract]

291. Wein, R. W., and D. A. MacLean. 1983*b*. The role of fire in northern circumpolar ecosystems. Scientific Committee on Problems of the Environment (SCOPE 18). John Wiley & Sons Ltd., Chichester, England. 322 pp.

Fifteen papers in this volume address past and present fire frequencies, physical effects of fire, concepts of fire effects on plant individuals and species, fire effects on selected vegetation zones, and fire control and management. A thorough review of all aspects of fire in the arctic and subarctic is presented. Two papers in this congress (Wein 1983; Wein and MacLean 1983*a*) are included in this annotated bibliography. [K–L–S]

292. Weiss, T. E., Jr. 1980. The effects of nutrient availability on the pitcher plant *Sarracenia flava* L. Ph.D. Dissertation. University of Georgia, Athens. 108 pp.

Both winter and summer burns caused earlier appearance of flowers and pitchers of trumpet-leaf. Pitcher height was reduced during the first postfire growing season, returning to control values in the second. No change in patterns of production followed the summer burn. Soil nutrient status was not significantly altered by either burn. Tissue nutrient changes following the burns were of short duration, lasting through most of the first postwinter burn growing season and through only the end of the growing season following the summer burn. In general, summer burns appeared to be less detrimental to growth of pitcherplants in south Georgia. [From author's abstract]

293. Weller, M. W. 1979. Small–mammal populations and experimental burning of Dewey's pasture, northwest Iowa, 1970–74. Iowa State J. Res. 53:325–329.

Most small mammals favored the more moist wetland edge. One April fire significantly reduced litter depth and height or species composition of vegetation. Mammal populations fluctuated greatly over the 5-year period with the dominant populations of masked shrews and meadow voles showing greatest variation. Thirteen-lined ground squirrels, northern short-tailed shrews, and meadow jumping mice increased on burned areas, whereas the masked shrews and meadow voles declined less on burned than on unburned areas. [From author's abstract]

294. Weller, M. W. 1981. Freshwater marshes: ecology and wildlife management. University of Minnesota Press, Minneapolis, MN. 146 pp.

This text is a general introduction to the subject for laypersons, students, and professionals in other fields. Fire is mentioned as one of the dominant forces causing change in marshes, largely through nutrient turnover and elimination of the bulk of plant biomass. Cautions regarding burning are provided. [K–L–S]

295. Wells, B. W. 1928. Plant communities of the coastal plain of North Carolina and their successional relationships. Ecology 9:230–242.

Fire is a major factor in all upland habitats where drought may occur. Fire also affects wetland communities in the coastal plain, initiating succession or maintaining seral stages. The swamp forest community changes to xeric shrub bog (pocosin) communities under certain conditions, including fire. Continued fire will change the pocosin to the grass-sedge bog community. Diagrams are provided of the successional sequences recognized. [K–L–S]

296. Wells, B. W. 1931. The vegetation and habitat factors of the coarse sands of the North Carolina coastal plain: an ecological study. Ecol. Monogr. 1:465–520.

The coarse sand, xeric vegetation, and fire interact to form remarkably stabilized fire subclimaxes of four types: xeric upland sands, mesic subsoil, semi-hydric transition areas, and

bogs. The vegetation and successional sequences are described, and various climatic, edaphic, and distributional factors are analyzed. [K–L–S]

297. Wells, B. W. 1942. Ecological problems of the southeastern United States coastal plain. Bot. Rev. 8:533–561.

Fire is more common in the coastal plain than in the adjoining piedmont. Marsh communities, despite their wet habitat, are nonetheless subject to major changes under impact by fire. In salt marshes, fire may change a marshhay cordgrass community to one dominated by salt marsh bulrush or Olney bulrush. Pocosins (shrub bogs) are maintained by fire, and Atlantic white-cedar bogs, which can be regenerated by fire over wet peat, can be destroyed by dry-season fires or consecutive burns. Throughout the coastal plain, greater fire frequency and intensity decrease humus accumulation and lead to fire–stabilized upland and lowland communities. [K–L–S]

298. Wells, B. W., and S. G. Boyce. 1953. Carolina bays: additional data on their origin, age, and history. J. Elisha Mitchell Sci. Soc. 69:119–141.

The catastropic meteorite origin of Carolina bays is discussed and reinterpreted with the conclusion that meteorites were indeed the physiographic origin of these basins. The author also proposes that the bay lakes were initiated by fire in post-glacial time and shoreline erosion has continued their development. Human alterations in the region encompassing Carolina bays include 300 years of agriculture, forestry, industry, and other land management. These relatively modern impacts, in addition to earlier burning by Native Americans, have made it impossible to estimate the original amount of pocosin vegetation in Carolina bays or to describe with certainty the vegetation preceding the advent of large-scale fires initiated by man. [K–L–S]

299. Wells, B. W., and L. A. Whitford. 1976. History of stream-head swamp forests, pocosins, and savannahs in the southeast. J. Elisha Mitchell Sci. Soc. 92:148–150.

Fires by Native Americans and later by white settlers initiated change of swamp forests to shrub bogs (pocosins), and with intensive burning, into grass-sedge bogs or savannas. With burns occurring as frequently as every decade, the deciduous forest largely disappeared or became dominated by pond pine and cane. Under yet more frequent burning, pine and cane were replaced by more fire resistant shrubs and trees such as redbay persea, sweetbay magnolia, fetterbush, and greenbrier. With even more extreme annual fire, shrubs disappear and are replaced by grasses, sedges, and forbs. Reduction of fire frequency leads to the reverse sequence of succession in these areas. [K–L–S]

300. Wells, C. G., R. E. Campbell, L. F. DeBano, C. E. Lewis, R. L. Fredrickson, E. C. Franklin, R. C. Froelich, and P. H. Dunn. 1979. Effects of fire on soils: a state-of-knowledge review. U.S. For. Serv. Gen. Tech. Rep. WO-7. 34 pp.

A summary of the literature on the effects of fire on soil properties is provided. More specific data are provided for certain important forest, brush, and rangeland types. Resultant effects on soils affect watershed nutrient fluxes and thus the subsequent alteration of streams and wetlands; 210 citations are listed. [K–L–S]

301. Wendel, G. W., T. G. Storey, and G. M. Byram. 1962. Forest fuels on organic and associated soils in the coastal plain of North Carolina. U.S. For. Serv., Southeast. For. Exp. Stn. Pap. 144. 46 pp.

Frequent and costly blowup wildfires occur in pocosins and are potential problems in control burning as well. Most blowup fires in pocosins are essentially uncontrollable and burn until the weather moderates or fuel is exhausted. This presents a silvicultural problem because pond pine management requires control burns of sufficient intensity to promote seed fall from serotinous cones and to prepare the seedbed. These fires are difficult to control and often burn deeply into the organic soil. To permit a better understanding of the factors favoring major fires, pocosin fuels were typed in terms of their species composition, height, and density, and fire rating classes for potential extreme fire behavior for each type of fuel were derived. [K–L–S]

302. Wharton, C. H., W. M. Kitchens, E. C. Pendleton, and T. W. Sipe. 1982. The ecology of bottomland hardwood swamps of the Southeast: a community profile. U.S. Fish Wildl. Serv., Biol. Serv. Progr. FWS/OBS–81/37. 133 pp.

Fire is not important as a natural disturbance in bottomlands because of the prevalence of water and lack of a substantial litter layer to carry fire. This is especially true of the wetter portions of alluvial floodplains, although drier forests can have fires as frequently as every 5 to 8 years, and it is conjectured that Native Americans maintained canebrakes in bottomlands by deliberate fall burning. Most fires are ground fires, which destroy all small vegetation, including tree reproduction, and damage the boles of larger trees. Some bottomland types are favored by fire if it is not too frequent (e.g., Atlantic white-cedar). [K–L–S]

303. Whipple, S. A., and D. White. 1977. The effect of fire in two Louisiana marshes. Assoc. Southeast. Biol. 24:95. (Abstract only)

The major effect of burning on composition of brackish marshes was to allow the appearance of saltmarsh bulrush and an increase in density of dominant species. The relatively small effect of burning in this study may be related to the long history of periodic fire on Louisiana marshes. Only long-term exclusion of fire will clarify fire effects on these wetlands. [From authors' abstract]

304. Whitehead, D. 1972. Development and environmental history of the Dismal Swamp. Ecol. Monogr. 42:301–315.

Pollen analyses indicate that the Dismal Swamp in southeastern Virginia is relatively young. The general sequence of vegetational change suggests a unidirectional climatic amelioration from conditions comparable to those in northern New England during the full glacial to a climate comparable to the present by 8,000 years BP. The cypress–gum swamps that have characterized the Swamp for the past 500 years have been variable both spatially and temporally, probably because of differences in water table, peat depth, fires, wind throws, and a variety of human disturbances. [From author's abstract]

305. Whitehead, D. R., and R. Q. Oaks, Jr. 1979. Developmental history of the Dismal Swamp. Pages 25–43 *in* P. W. Kirk, ed. The Great Dismal Swamp. Proceeding of a symposium sponsored by Old Dominion University and United Virginia Bank—Seaboard National 14 March 1974. University Press of Virginia, Charlottesville.

The Swamp is dependent upon the maintenance of a considerable thickness of peat which in turn depends upon the preservation of a normal water budget and unobstructed patterns of water flow. The dynamics of the peat surface are currently threatened by ditching, fires, tree farming, and a variety of other land uses. Fires have increased in Dismal Swamp in modern times, largely because of man. [K–L–S]

306. Wilbur, R. B. 1986. The effects of fire on nitrogen and phosphorus availability in a North Carolina coastal plain pocosin. Ph.D. Dissertation. Duke University, Durham, NC. 143 pp.

[See Wilbur and Christensen 1983]

307. Wilbur, R. B., and N. L. Christensen. 1983. Effects of fire on nutrient availability in a North Carolina coastal plain pocosin. Am. Midl. Nat. 110:54–61.

Nutrient availability was monitored in recently burned and unburned blocks of a large ombrotrophic shrub-bog in North Carolina. Availability of Mg, K, PO_4–P, NH_4–N, and NO_3–N was significantly increased, whereas available Ca was lower in the burned area than in the unburned area. Concentrations of several nutrients, particularly PO_4–P and NO_3–N, were considerably more variable spatially in the burned area. Nutrient concentrations in peat from the clipped plots were not different from those of unmanipulated areas. Bioassays using pond pine revealed phosphorus deficiency in unburned peat which was ameliorated by burning. [From authors' abstract]

308. Willner, G. R., J. A. Chapman, and D. Pursley. 1979. Reproduction, physiological

responses, food habits, and abundance of nutria on Maryland marshes. Wildl. Monogr. 65. 43 pp.

Olney bulrush is dominant on many Maryland coastal marshes where controlled burning is practiced. Burning did not appear to retard deterioration (sinking of land; increase in open water) at Blackwater National Wildlife Refuge. Early burning may have slowed the rate of thinning, but did not reverse the negative trends in marsh density. [K–L–S]

309. Winchester, B. H., J. S. Bays, J. C. Higman, and R. L. Knight. 1985. Physiography and vegetation zonation of shallow emergent marshes in southwestern Florida, USA. Wetlands 5:99–118.

Important determinants of vegetation zonation in southwestern Florida freshwater wetlands were water depth, substrate type, fire, and disturbance from feral hog rooting and cattle grazing. [K–L–S]

310. Winkler, M. G., and C. B. DeWitt. 1985. Environmental impacts of peat mining in the United States: documentation for wetland conservation. Environ. Conserv. 12:317–330.

Fire and air pollution problems are listed together as one of seven crucial local and regional biophysical effects of peat mining. Examples of difficult (or impossible) to extinguish peat fires are provided; the value of undisturbed peatlands is emphasized. [K–L–S]

311. Woodall, S. L. 1983. Establishment of *Melaleuca quinquenervia* seedlings in the pine–cypress ecotone of southwest Florida. Fla. Sci. 46:65–72.

Attempts to control cajeput tree with fire, herbicides, felling, and bulldozing have been thwarted by dense regeneration from seeds released after disturbance. Management recommendations include killing young trees and withholding fire from October to late December. In the following dry season (November to April) a moderately hot fire across seedlings will kill some and trigger further germination. Two years after first treatment, remaining individual seedlings can be grubbed or treated with herbicide. In general, fire brings seed from soil storage and stimulates growth, so in itself it is not a control measure. In combination with selected seed release and control of surviving seedlings, however, fire can be used to remove cajeput tree from the pine–cypress ecotone. [K–L–S]

312. Wright, H. A., and A. W. Bailey. 1980. Fire ecology and prescribed burning in the Great Plains–a research review. U.S. For. Serv. Gen. Tech. Rep. INT–77. 60 pp.

Basic ecological information, vegetative descriptions, and fire effects data for the shortgrass, mixedgrass, and tallgrass prairies in the southern, central, and northern Great Plains are presented. In an appendix, fire effects data have been tabulated for each species for quick reference. Prescription guides are provided for all major vegetation types where prescribed burning data have been collected. Although only a short section on marsh burning (using one example from the literature) is provided, this paper provides a guide for planning burns for best effect in prairie areas where burns cannot be confined to or are not desired only in marsh areas. [From authors' abstract]

313. Wright, H. A., and A. W. Bailey. 1982. Fire ecology: United States and southern Canada. John Wiley & Sons Ltd., New York. 501 pp.

This general review text emphasizes the historical and present impacts of fire on vegetation, particularly native plant communities. The role of fire in major ecosystems of the United States and southern Canada, including grassland, semi-desert, grass-shrub, chaparral and oak brush, pinyon-juniper, ponderosa pine, Douglas-fir, spruce-fir, red and white pine, coast redwood and giant sequoia, and southeastern forest biomes, is discussed. The principles and use of prescribed burning to achieve management objectives are described. Responses of small mammals, birds, big game, furbearers, stream fauna, and marsh species to fire are mentioned. In wetlands, burning can: (1) make new green shoots, roots, and rhizomes of sedges and grasses available to geese; (2) eliminate accumulations of organic matter and impenetrable growth of climax species such as common reed, bulrush, sawgrass, smooth

cordgrass, and common cattail, thus increasing wetland suitability for waterfowl and muskrats; 3) allow seeds to become available to waterfowl; and (4) create edge and deep pools for waterfowl nesting and feeding. [K–L–S]

314. Wright, H. E., Jr. 1981. The role of fire in land/water interactions. Pages 421–444 *in* H. A. Mooney, T. M. Bonnicksen, N. L. Christensen, J. E. Lotan, and W. A. Reiners, tech. coords. Proceedings of the conference: fire regimes and ecosystem properties. U.S. For. Serv. Gen. Tech. Rep. WO-26.

Forest fire has low potential to produce flooding and eutrophication of streams and lakes. A temporary increase in runoff, in part because of decreased evapotranspiration, and mass transport of nutrients and cations commonly occurs, but no algal blooms were detected in three studies (Washington, Minnesota, Ontario). Extent of fires is commonly limited by natural firebreaks provided by lakes and streams. Lake sediment studies document forest history, including fire frequency, and can illustrate shifts from fire-adapted forests to fire resistant forests, or the reverse. [From author's abstract]

315. Wright, H. E., and M. L. Heinselman. 1973. Introduction [to symposium entitled—The Ecological Role of Fire in Natural Conifer Forests of Western and Northern North America]. Quat. Res. (NY) 3:319–328.

This introduction to the symposium held at the annual meetings of the Ecological Society of America and American Institute of Biological Sciences at the University of Minnesota in 1972, draws together some common themes in the eight papers presented and published as Quaternary Research 3:317–513. Principles viewed as running through the symposium, included: (1) fire as an influence on the physical–chemical environment; (2) fire as a regulator of dry-matter accumulation; (3) fire as a controller of plant species and communities; (4) fire as the determinant of wildlife habitat patterns and populations; (5) fire as controller of forest insects, parasites, fungi, etc.; and (6) fire as the controller of major ecosystem processes and characteristics. Papers by Rowe and Scotter (1973) and Vierick (1973) from this symposium are included in this bibliography. [K–L–S]

316. Yancey, R. K. 1964. Matches and marshes. Pages 619–626 *in* J. P. Linduska, ed. Waterfowl tomorrow. U.S. Fish Wildl. Serv., Washington, DC.

Fire "is a destroying angel, whose ecological mission it is to cleanse," that is, to keep waterfowl marshes from becoming brushy bogs or wooded swamps. Root burns set succession back to a subclimax plant community that is more productive of food for waterfowl and more open for feeding. Brackish marshes along the Gulf of Mexico are fertilized by ash deposits left by fire, as these contain potassium, calcium, phosphorus, magnesium, and chlorides. Cover burning eliminates accumulated growth and makes roots, rhizomes, and young shoots available to grazing snow geese. Peat burns create holes in the marsh floor, which become ponds and open water areas. As a waterfowl management practice, fire serves best in a marsh over which water control can be exercised. Burning should not be done during or just prior to waterfowl nesting, unless long–range gains in improved habitat outweigh immediate losses of nests and young birds. [K–L–S]

317. Young, R. P. 1986. Fire ecology and management in plant communities of Malheur National Wildlife Refuge, southeastern Oregon. Ph.D. dissertation. Oregon State University, Corvallis. 183 pp.

Experimental burns during periods of vegetation dormancy were conducted to evaluate fire behavior and effects in wetland and upland habitat, and fire effects on Canada thistle. Wetland plant communities were monotypic stands of tule bulrush, giant burreed, awned sedge, Baltic rush, and common spikerush; upland communities included rubber rabbitbrush/basin wildrye and black greasewood/seashore saltgrass shrub-grasslands and creeping wildrye mesic meadow. Successful burns were conducted in a wide range of conditions, provided fuels were dry and winds were steady. Burning prescriptions and techniques are provided. Vegetation response was insensitive to timing within the dormant period. Fire significantly altered vegetation

structure and community function, but responses were often species-specific. Aboveground herbage production increased for 1 to 2 years in all but burreed communities; shoot density of rhizomatous species increased after burning, and shrubs sprouted and grew vigorously, quickly replacing canopy cover and volume. Reproductive effort among species varied markedly after fire. Indications are that the communities will return to preburn status in 3 to 5 years. Relative abundance of thistle decreased after burning, suggesting that dormant season burning may be useful in halting its invasion or spread by maintaining productive stands of native vegetation. [From author's abstract]

318. Young, R. P., and R. F. Miller. 1984. Effects of prescribed burning on upland vegetation of Malheur National Wildlife Refuge, southeast Oregon. Soc. Range Manage. Annu. Meeting 37:[14]. (Abstract only)

[See Young 1986]

319. Zontek, F. 1966. Prescribed burning on the St. Marks National Wildlife Refuge. Proc. Annu. Tall Timbers Fire Ecol. Conf. 5:195–201.

Prescribed burning is a management tool used to benefit waterfowl on the St. Marks National Wildlife Refuge, Florida. Geese prefer marsh areas that are burned. The effectiveness of fire in marsh management often depends on the ability to flood burned marshes before new growth starts. [K–L–S]

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Subject Index—Annotated Bibliography

This index is cross-referenced in eight major categories (Effects of fire upon **Air Quality; Livestock/Grazing Management; Refuges, Parks and Wildlife Management Areas; Soils; Vegetation, General; Water Quality; Wetlands;** and **Wildlife**. The citations on Wetlands are further divided among three Wetland Systems and five Wetland Classes taken from Cowardin et al. (1979.) Classification of wetlands and deepwater habitats of the United States. *U.S. Fish Wildl. Serv. FWS/OBS-79/31.* 131 pp.) as follows: **Estuarine System—Emergent and Scrub-Shrub Wetlands and Forested Wetlands; Palustrine System—Emergent and Moss-Lichen Wetlands and Scrub-Shrub and Forested Wetlands**; and **Riverine/Lacustrine System Wetlands.** Complete definitions of these Wetland Systems and Classes as well as photographs of representative examples from throughout North America may be found in Cowardin et al. (ibid), which may be obtained from the Publications Unit of the U.S. Fish and Wildlife Service, Room 148 Matomic Building, Washington, DC 20240. The citations on **Wildlife** are similarly divided into categories as follows: **Invertebrates; Amphibians, Reptiles and Fish; Nongame Birds and Mammals; Upland Game (birds and mammals); Furbearers; Big Game;** and **Waterfowl, Shore, and Marsh Birds.**

Fire, Effects On:

Appendix A

The Literature on Fire Indexed in *Wildlife Review* 1935 through September 1987.

(Numbers 1–206)

Introduction

Wildlife Review has compiled the literature on wildlife management and research for more than 50 years. Coverage has expanded over time with the current volumes addressing substantially more topics, greater numbers of publications, and greater numbers of key words for each citation. Originally hand-collected, the texts are now computer-generated and form an interactive data base used by both the national and international research and management communities.

Titles included in *Wildlife Review* address some aspect of the life history or management of a "wildlife species." "Wildlife" in this context generally includes all terrestrial vertebrates, marine mammals, and nonobligate aquatic species. Fish and other aquatic species are not addressed; invertebrates are addressed only in the context of their relationship to vertebrate species as prey, parasites, etc.; and publications that discuss habitat per se, for example, without discussing its relevance to or interaction with wildlife, do not appear. This bibliography on fire–wildlife relationships is thus unlike a bibliography that would be formed if one generally searched the literature for titles on fire–wildlife relationships. It is therefore a unique review, with a purposefully narrow focus despite its broad coverage of literature and topics.

Development of the Bibliography

Titles included in this supplemental bibliography have appeared in *Wildlife Review* 1935–September 1987 (numbers 1–206). [The last date for an item to enter Number 206 was 31 July 1987.] To obtain pertinent titles, *Wildlife Abstracts* (1935–51, 1952–55, 1956–60, 1961–70), which summarized volumes 1–140 of *Wildlife Review*, were searched manually. Citations from *Wildlife Review* volumes 141–206 were obtained by machine search of the records in the files of the Data Base Section of the Office of Information Transfer, which is responsible for compiling and publishing *Wildlife Review* and *Wildlife Abstracts*. The distribution of the 190,861 titles searched in this process was:

1935–51	10,000
1952–60	14,481
1961–70	24,440
1971–80	54,802
1981–87	87,138

This 1935–1987 bibliography is incomplete to the extent that some pertinent titles were not indexed in the early years of *Wildlife Review* because of their emphasis upon fire management, fire behavior, or fire suppression, topics not then viewed as related to wildlife per se. Notwithstanding, within the category of fire as it relates to wildlife, summarization of titles indexed in *Wildlife Review* does provide the most complete bibliography obtainable from a single source.

Each citation in this appendix has a unique identifying number which is keyed to the Author Index. Within each appendix citation is a reference to the issue of *Wildlife Review* in which the citation originally appeared. (Addresses of authors and other pertinent data may be found in the *Wildlife Review* citations.)

The appendix text was computer-generated with the software used to print *Wildlife Review* from a special file incorporating only the citations on fire since each citation had to be re-indexed for this bibliography. The citations are listed in subject categories that best describe the content of the texts as they relate

to fire–wildlife relationships. Because of the limitations of the printing software, titles could only be entered once in the text of the bibliography, that is, each item could enter the subject categories only once. This presented an indexing problem because many titles in the bibliography addressed several of the subjects we chose as major topical areas for presentation. To facilitate use of the bibliography, we therefore developed and strictly followed a set of indexing rules in preparing the text. Each citation was, in effect, run through a hierarchical indexing "key" (Table A1). The first instance in which a fit was found with the key was used as the major subject heading for a given citation.

Several practical "rules" thus apply to the use of this bibliography. First, with reference to Table A1, note that any citation that addressed issues in refuges, parks, wilderness, and natural areas sorted out initially regardless of the content of the text. This category therefore should always be searched for pertinent titles in addition to whatever further subject matter category is selected for review. At the other extreme, the categories that addressed "types" of fires, controlled or wild, only contain citations that could not be indexed by categories 1 through 9 (Table A1). Thus, an attempt to locate all citations on either of these subjects cannot be very efficiently initiated with this literature compilation, but alternative sources, such as FIREBASE, or some of the commercially available data bases, would be the location of choice for such searches in any case.

Throughout, citations were preferentially sorted by wildlife species of major concern instead of habitat "type." Our expectation was that this approach would match current emphasis upon management of habitat for wildlife species instead of management of habitat per se. Unfortunately, with single entry of each citation, search of this bibliography for information on particular habitats is thus difficult. We, therefore, suggest additional search of the literature with specific geographic constraints when particular ecosystems are the major concern.

During preparation of drafts of the manuscript, several reviewers suggested expansion of the categories we used to sort the citations. This required re-coding and re-keying the entries several times as we developed finer distinctions among categories. To most efficiently accomplish these revisions, we successively changed codes within larger categories. Thus, the final bibliography, when sorted as per Table A1, mixed the sequence numbers which destroyed their utility as unique identifiers of each citation. We thought it best to maintain this capability, so we printed the citations by sequence number within subject matter category. Thus, the final text does not reflect the hierarchical organization of the indexing key. Nonetheless, one can easily access it by reference to the Subject Index for this Appendix. Since only 942 titles are included, the search for pertinent citations in any category is not an arduous task.

We have not attempted to summarize or analyze the data appearing in Appendix A. Nonetheless, managers concerned with fire management planning or fire effects evaluation should be able to scan the lists quickly for recent titles pertinent to their ecosystems or species of interest.

The Fire–Wildlife Literature 1935–September 1987

The literature on fire–wildlife relationships, sorted by 11 major and 16 minor categories, appears on the following pages. This review is best used by first consulting Table A1 to review the hierarchical indexing key and select the subject areas of potential interest. Then the Subject Index for Appendix A should be consulted for guidance to the inclusive citation numbers in the area of interest. Finally, turn to the potentially appropriate citations and review each for pertinence to the area of concern.

Subject Index For Appendix A
The Literature On Fire–Wildlife Relations Indexed In *Wildlife Review* 1935–September 1987

Major category Inclusive citations

Table A1. *Hierarchical indexing key for the subject categories used to sort the citations on fire found in Wildlife Review 1935–September, 1987.*

Major category	(Minor category)
1. Use of fire in refuges, parks, wilderness, and natural areas	
2. Effects of fire on soils	
3. Effects of fire on marshes and wetlands	
4. Effects of fire on wildlife: general and multispecies studies	
5. Effects of fire on mammals	(small game) (big game) (furbearers, predators) (other mammals; mammals general)
6. Effects of fire on birds	(nongame) (game–upland) (game–waterfowl) (other birds and multispecies studies)
7. Effects of fire on herpetofauna	
8. Effects of fire on vegetation	(general) (grassland) (shrub/scrub brushland, savannah, and desert) (chaparral, Mediterranean) (heath) (range–general) (temperate/tropical woodland/forest) (boreal, subalpine, and bog vegetation; taiga and tundra)
9. Controlled/prescribed burns	
10. Use of fire in habitat management	
11. Wildfire and wildfire management	

EFFECTS OF FIRE ON SOILS

001 Amaranthus, M. and D. H. McNabb. BARE SOIL EXPOSURE FOLLOWING LOGGING AND PRESCRIBED BURNING IN SOUTHWEST OREGON. *Proc. Soc. Am. For. 1983* p. 234-237. 1984. WR 194

002 Austin, R. C. and D. H. Baisinger. SOME EFFECTS OF BURNING ON FOREST SOILS OF WESTERN OREGON AND WASHINGTON. *J. For.* 53(4):275-280. Apr. 1955. WR 80-48

003 Biswell, H. H.; A. M. Schultz; D. W. Hedrick and J. I. Mallory. FROST HEAVING OF GRASS AND BRUSH SEEDLINGS ON BURNED CHAMISE BRUSHLANDS IN CALIFORNIA. *J. Range Manage.* 6(3):172-180. May 1953. WR 74-46

004 Burns, Paul Y. EFFECT OF FIRE ON FOREST SOILS IN THE PINE BARREN REGION OF NEW JERSEY. *Ph.D. thesis, Yale Univ.* 1949. WR 63-31

005 Cheruiyot, S. K.; W. H. Blackburn and R. D. Child. INFILTRATION RATES AND SEDIMENT PRODUCTION OF A BRUSH GRASSLAND AS INFLUENCED BY VEGETATION AND/OR PRESCRIBED BURNING, KIBOKO, KENYA. *Soc. Range Manage. Annu. Meeting* 37:[13.] 1984. Abstract only. WR 198

006 Christensen, N. L. THE BIOGEOCHEMICAL CONSEQUENCES OF WILDFIRE: A COMPARATIVE APPROACH. *Int. Congr. Ecol.* 4:115. 1986. Abstract only. WR 203

007 Fuller, W. H.; Stanton Shannon and P. S. Burgess. EFFECT OF BURNING ON CERTAIN FOREST SOILS OF NORTHERN ARIZONA. *For. Sci.* 1(1):44-50. Mar. 1955. WR 86-26

008 Greene, S. W. EFFECT OF ANNUAL GRASS FIRES ON ORGANIC MATTER AND OTHER CONSTITUENTS OF VIRGIN LONGLEAF PINE SOILS. *J. Agric. Res.* 50(10):809-822. 15 May 1935. WR 4-13

009 Helvey, J. D.; A. R. Tiedemann and T. D. Anderson. PLANT NUTRIENT LOSSES BY SOIL EROSION AND MASS MOVEMENT AFTER WILDFIRE. *J. Soil Water Conserv.* 40(1):168-173. 1985. WR 197

010 McKee, William H., Jr. IMPACTS OF PRESCRIBED BURNING ON COASTAL PLAIN FOREST SOILS. *Proc. Soc. Am. For. 1986* p. 107-111. 1987. WR 206

011 Pearse, A. S. EFFECTS OF BURNING-OVER AND RAKING-OFF LITTER ON CERTAIN SOIL ANIMALS IN THE DUKE FOREST. *Am. Midl. Nat.* 29(2):406-424. Mar. 1943. WR 37-17

012 Scotter, George W. EFFECTS OF FOREST FIRES ON SOIL PROPERTIES IN NORTHERN SASKATCHEWAN. *For. Chron.* 39(4):412-421. Dec. 1963. WR 113-14

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Appendix A

Appendix B
How to Obtain Articles Cited In This Document or Obtain Additional Literature Review

Most of the citations in this bibliography may be obtained locally or through means of interlibrary loan. Field personnel should avail themselves of the services provided by local public and nearby college and university libraries before requesting additional assistance. Loan privileges may usually be obtained for government and other officially affiliated employees; interlibrary loan services are usually provided at no charge to patrons. Most libraries have interlibrary loan capability, and can provide other assistance in locating the items one needs.

Staff of Department of the Interior Bureaus may obtain additional assistance from their Regional Office librarian or the Natural Resources Library:

Interlibrary Loan
Natural Resources Library
18th and C Steets, NW
U.S. Department of the Interior
Washington, DC 20240

FTS: 343–5815
Commercial: 202/343–5815

For Departmental personnel in the field, the Natural Resources Library will (1) lend books in its collection; (2) provide copies of journal articles from its holdings; (3) obtain copies of journal articles from other libraries, if a free source is available; (4) provide advice on means to locate unusual, out-of-print, or otherwise immediately unavailable items; and (5) perform additional literature reviews if budgets permit. To expedite processing, use a request form to obtain interlibrary loan or other documents (Attachment B1) or to request literature reviews (Attachment B2). Ranking your requests in order of need will assist the library staff to meet your needs. Note that although there is no limit to the number of requests that may be submitted to the Natural Resources Library, the volume of requests handled by the Library requires that no more than 10 requests from an individual patron be submitted at one time.

Similar assistance for staff of the Department of Agriculture is available by contacting Regional libraries, Forest and Range Experiment Station libraries, or the National Agricultural Library:

Public Services Section
National Agricultural Library
U.S. Department of Agriculture
Beltsville, MD 20705

FTS: 344–3834
Commercial: 301/344–3834

In addition, personnel of the U.S. Fish and Wildlife Service may contact Research and Development for assistance in locating items of particular interest as follows:

Office of Information Transfer
U.S. Fish and Wildlife Service
1025 Pennock Place, Suite 212
Fort Collins, CO 80524

FTS: 323–5401
Commercial: 303/493–8401

The Office of Information Transfer can also provide a Technical Information Package entitled: How to Get the Publications You Need: A Guide For Field FWS Personnel Without Access to Library Services (Hindman and Uskavitch 1987) which provides additional information on obtaining library assistance. The Office of Information Transfer acts as liaison between the research and operational communities in the Fish and Wildlife Service, and provides technical assistance of all types at no charge to the requester.

Attachment B1

Mail to:

Natural Resources Library
U.S. Department of the Interior
18th and C Streets NW
Washington, DC 20240

INTERLIBRARY LOAN REQUEST

Book or Article title: ____

Author: ____

Book: Publisher: ____________ Date: __________ Edition: ______________

Journal or serial title: ____

Volume: _______ Number: _______ Month, Day, Year: _________ Page: ______

Source of reference: ____

Requester: ______________________________ Telephone: ________________

Address: ____

____

SEARCH REPORT: Call Number: ____________ OCLC Number: _________

Library does not own______ Not on shelf_____ Request on ILL

This is ________ of _______ requests (i.e. 2nd of 4) ____________________

Attachment B2

SEARCH REQUEST

COMPUTERIZED SEARCH SERVICES
Natural Resources Library
18th and C Streets, NW
Washington, DC 20240

Requester ______________________________ Signature ____________________
(Please print or type)

For official use of ______________________ Date ____________________
(Bureau, Office, Agency)

Mailing Address _________________________ Date Rec'd ____________________
(Street)

______________________________________ Telephone No. ____________________
(City) (State) (Zip)

1. Please find citations on the following subject:
(Be specific and precise in formulating your request. Stipulate particularly what you do not want.)

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2. Suggested search words: ____

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3. Please list the complete citations to two or three of the most useful articles on your search topic and/or indicate two or three of the most important authors (or organizations) publishing on your topic. Complete names are helpful.

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4. Language limitation:

Any Language ____________ English Language Only ________________

5. Do you wish to exclude references to particular types of documents?

Exclude:

_______ Journal articles
_______ Conference papers
_______ Patents
_______ Books
_______ Dissertations
_______ Reports

6. Would you prefer:

_____ a comprehensive search that retrives most of the references relevant to your problem, but which may also retrieve many references not relevant?

_____ a narrow search that may retrieve fewer references relevant to your problem, but which also retrieves fewer non-relevant references?

7. Can you estimate the number of relevant documents?

a) you think may be present in literature ________________
b) you would like to retrieve and get references for __________

8. If you have previously done a literature search (manually or by computer on this problem or a closely related problem, please indicate, if possible, what was searched, what difficulties were encountered, and the overall result of the search.

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9. Please give a title to your problem.

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U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.